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NACA

RESEARCH MEMORANDUM

EFFECTS OF SIZE OF EXTERNAL STORES ON THE AERODYNAMIC CHARACTERISTICS OF AN UNSWEPT AND A 45° SWEPTBACK WING OF ASPECT RATIO 4 AND A 60° DELTA WING AT MACH NUMBERS OF 1.41, 1.62, AND 1.96

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NATIONAL ADVISORY COMMITTEE
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SUMMARY

An investigation has been made in the Langley 9- by 12-inch supersonic blowdown tunnel to determine the effects of varying the size of external stores on the lift, drag, and pitching-moment characteristics of three wings; an unswept and a 45° sweptback wing having aspect ratios of 4 and taper ratios of 0.6, and a 60° delta wing at Mach numbers of 1.41, 1.62, and 1.96. The size of a Douglas Aircraft Company, Inc. store having a fineness ratio of 8.58 was systematically varied at the 80-percent-semispan station of the unswept and sweptback wings and at the 60-percent-semispan station of the delta wing. Several of the stores were also tested at other locations on the outer 60 percent of each of the wing semispans in order to obtain data complimentary to data obtained in previous tests. The Reynolds numbers of the investigation based on the wing mean aerodynamic chords ranged from 1.1×10^6 to 2.8×10^6.

INTRODUCTION

External stores have been used to advantage in carrying fuel and ordnance on aircraft and a fairly large amount of information is available concerning their influence on wing aerodynamic characteristics at subsonic and transonic speeds (for example, see refs. 1 to 8). It is desirable to know whether stores can still be used advantageously at supersonic speeds, but little information is available since the few experimental investigations to date (refs. 9 to 11) have been quite limited in scope. Consequently, in order to obtain comprehensive experimental information at supersonic speeds, an exploratory program has been initiated in the Langley 9- by 12-inch supersonic blowdown tunnel to study the effects of stores on the aerodynamic characteristics of several wing configurations. The investigations of the effects of location of one size store on the aerodynamic characteristics of an unswept, a 60° delta, and a 45° sweptback wing were reported in references 12, 13, and 14, respectively.

This paper contains data obtained for the same three wings with five different external stores ranging in size from about a 200-pound bomb to a large jet engine nacelle (based on assumed wing areas of 500, 600, and 750 square feet for an unswept, a 45° sweptback, and a 60° delta wing, respectively.) The stores had fineness ratios of 8.58 and a Douglas Aircraft Company, Inc. store shape. The store size was systematically varied at the 80-percent-semispan station of the unswept and sweptback wing and at the 60-percent-semispan station of the delta wing at Mach numbers of 1.41, 1.62, and 1.96 and at wing lift coefficients up to 0.80. A limited number of stores were also tested at other locations on the outer 60 percent of the wing semispans in order to obtain data complimentary to data contained in references 12 to 14. The Reynolds numbers of the investigation based on the wing mean aerodynamic chords ranged from 1.1×10^6 to 2.8×10^6. The data are presented without analysis to expedite publication.

COEFFICIENTS AND SYMBOLS

C_L lift coefficient, Lift/qS

C_D drag coefficient, Drag/qS

C_m pitching-moment coefficient, $\frac{\text{Pitching moment about } 0.25\bar{c}}{qS\bar{c}}$

dC_m/dC_L rate of change of pitching-moment coefficient with lift coefficient

ΔC_m increment in wing pitching-moment coefficient caused by addition of external store

ΔC_D increment in drag coefficient due to addition of external store

q free-stream dynamic pressure

S semispan wing area

c	wing or strut chord
$\bar{c}$	wing mean aerodynamic chord
b	wing span, twice distance from wing-root chord to wing tip
λ	ratio of wing-tip chord to wing-root chord
A	aspect ratio, $b^2/2S$
$\Lambda_{c/4}$	sweepback of wing quarter-chord line
Λ_{LE}	sweepback of wing leading edge
t	strut thickness
d	store diameter
l	store length
l/l_{basic}	ratio of store length to basic store length (gross design volume of basic store approximately equal to 414 gallons based on assumed wing areas of 500, 600, and 750 sq ft for unswept, 45° sweptback, and 60° delta wing, respectively).
x	chordwise distance from line perpendicular to $\bar{c}$ at quarter-chord station to store $0.4l$ point
y	spanwise distance from wing-root chord to store center line
z	vertical distance from point of maximum thickness on wing lower surface to store center line
α	angle of attack
$\Delta\alpha$	increment in wing angle of attack due to addition of external store
R	Reynolds number based on $\bar{c}$

MODELS

The principal dimensions of the three semispan models used in this investigation are contained in references 12 to 14. The sections taken parallel to the air stream were for the unswept, the 45° sweptback, and

60° delta wing, NACA 65A004, 65A006, and 65A003 airfoil sections, respectively. The three solid wings were fabricated from SAE 4130 heat-treated steel.

External stores of various size having a Douglas Aircraft Company, Inc. (DAC) store shape of fineness ratio 8.58 were tested on the outer 60 percent of the three wing semispans. The locations at which each store was tested are fully described in figure 1. The center lines of all stores were within 1° of being parallel to the body axis. All the stores were molded of plastic with the exception of the largest store, $\frac{l}{l_{basic}} = 2.00$, which was fabricated from aluminum. The store designated as basic is that store which was tested in the investigations of store location of references 12 to 14 and which was designed to have a gross volume of 414 gallons based on assumed wing areas of 500, 600, and 750 square feet for an unswept, a 45° sweptback, and a 60° delta wing, respectively (fig. 2). The volume of the store varies as the cube of the store diameter and is approximately equal to $4d^3$. Figure 3 contains photographs of the five different stores that were tested.

Brass struts which were pinned and sweated to the wing lower surface were used to attach the stores to the wings. The struts had NACA 65A airfoil sections. The thickness ratios and chords of the various struts which were exposed to the air stream are given in the fol-fowing table:

$\frac{l}{l_{basic}}$	Wing					
	Unswept		Swept 45°		Delta	
	Strut c	Strut t/c	Strut c	Strut t/c	Strut c	Strut t/c
0.25	------	---	$0.235\bar{c}$	10.0	-------	----
0.50	$0.514\bar{c}$	5.6	------	----	$0.122\bar{c}$	10.0
1.00	$0.514\bar{c}$	5.0	------	----	------	----
1.26	------	---	$0.469\bar{c}$	10.0	$0.366\bar{c}$	5.5

For the unswept wing, a 60° sweptforward strut with its leading edge intersecting the wing quarter-chord line was used to position the basic store at $\frac{y}{b/2} = 0.80$ and $\frac{z}{d} = 1.50$ to obtain data comparable to that obtained with the basic unswept strut of reference 12. (See fig. 1.) For the 45° sweptback wing, fabrication difficulties made it necessary to use a strut sweptforward 45° from the wing leading edge to position the 25-percent-length store. The leading edge of the strut attaching the 50-percent-length store to the delta wing was located $0.21l$ from the store nose. The leading edge of the other exposed struts, which were unswept, coincided with the wing leading edge.

TUNNEL

The Langley 9- by 12-inch supersonic blowdown tunnel in which the present tests were made utilizes the compressed air of the Langley 19-foot pressure tunnel. The air enters at an absolute pressure of about $2\frac{1}{3}$ atmospheres, is conditioned to insure condensation-free flow by being passed through a silica-gel dryer and then through banks of finned electrical heaters. The criteria for the amount of drying and heating required were obtained from reference 15. Extensive calibration measurements had been made previously with no model in the test section and a summary of these measurements is contained in reference 16. These measurements are also briefly summarized in the following table:

Variables \ Average Mach number	1.41	1.62	1.96
Maximum deviation in Mach number	±0.02	±0.01	±0.02
Maximum deviation of ratio of static to stagnation pressure, percent	±2.0	±1.3	±2.2
Maximum deviation in stream angle, deg	±0.25	±0.20	±0.20

The average dynamic pressure and Reynolds numbers for the present investigation are given in table I. The test Reynolds number decreased about 3 to 4 percent during the course of each run because of the decreasing pressure of the inlet air.

TEST TECHNIQUE

The semispan wing models used in this investigation were cantilevered from a strain-gage balance which mounts flush with the tunnel wall and rotates with the model through the angle-of-attack range. A test body was attached to each of the wings and loads were measured on the wing-body combinations. The test body consisted of a half body of revolution and a 0.25-inch shim which was used to raise the half body of revolution off the tunnel wall and thus minimize the effects of the tunnel-wall boundary layer on the flow over its surface (ref. 17). A gap of about 0.010 inch was maintained between the test body and the tunnel wall under a no-load condition. There was some indication that at a Mach number of 1.41 the data of the present investigation might have been influenced by the reflection of the model bow wave from the tunnel wall at an angle of attack of 12°.

ACCURACY OF DATA

From a general consideration of the balance calibration accuracy and the repeatability of data, the accuracy of the force and moment measurements, in terms of coefficients, are believed to be about as follows:

C_L . . . . ± 0.005
C_D . . . . ± 0.001
C_m . . . . ± 0.002

For lift coefficients above 0.60, errors in drag coefficient in excess of ± 0.001 could well exist. The angle-of-attack values are believed to be accurate within $\pm 0.05^\circ$.

RESULTS

Lift, pitching moment, and drag data are presented herein without analysis for the wing-body combination and for the wing-body-store combinations. The aerodynamic characteristics of the body alone are contained in references 12, 13, and 14 for the unswept, the 60° delta, and the 45° sweptback wing, respectively. Figures 4 to 21 present the variations of lift coefficient with angle of attack and pitching-moment coefficient and drag coefficient with lift coefficient for the wing-body-store combinations at Mach numbers of 1.41, 1.62, and 1.96. Because the test body was an arbitrary configuration, the force and moment data, which are gross measurements, would not have any direct application to a particular wing-body-combination. It is believed, however, that the use of a different test body would not appreciably affect the qualitative results. From these data, values of dC_m/dC_L and increments of pitching-moment coefficient and angle of attack at various lift coefficients $\left(C_L = 0,\ 0.20,\ \text{and}\ 0.40\right)$ due to the addition of the store have been obtained and are presented in figures 22 to 24 as functions of store size. Similar summary plots showing the effects of store size on the drag increments caused by the addition of the stores to the wings are presented in figure 25. The data of figures 22 to 25, although plotted against store size, show some effects of store location since the various size stores were not all tested at the same chordwise location on the 45° swept and the 60° delta wing and since the values of z/d for the largest stores $\left(\frac{l}{l_{basic}} = 2.0\right)$ were slightly less than for the other stores. Data for the basic stores were obtained from references 12 to 14.

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REFERENCES

1. Muse, T. C., and Radey, K.: Aerodynamic Characteristics of Several External Store Installations on a Swept-Wing Hypothetical Bomber. Rep. No. ES-15456, Douglas Aircraft Co, Inc., Aug. 16, 1950.

2. Tamburello, V., and Burgan, Elmer: Exploratory Wind-Tunnel Tests of External Stores Mounted in Various Locations on the Wing of a 0.17-Scale Model Jet-Fighter Type Airplane. Rep. C-453 Aero. 806, David W. Taylor Model Basin, Navy Dept., Sept. 1951.

3. Spreeman, Kenneth P., and Alford, William J., Jr.: Investigation of the Effects of Geometric Changes in an Underwing Pylon-Suspended External-Store Installation on the Aerodynamic Characteristics of a 45° Sweptback Wing at High Subsonic Speeds. NACA RM L50L12, 1951.

4. Silvers, H. Norman, King, Thomas J., Jr., and Pasteur, Thomas B., Jr.: Investigation of the Effect of a Nacelle at Various Chordwise and Vertical Positions on the Aerodynamic Characteristics at High Subsonic Speeds of a 45° Sweptback Wing With and Without a Fuselage. NACA RM L51H16, 1951.

5. Alexander, Sidney R.: Effect of Strut-Mounted Wing Tanks on the Drag of NACA RM-2 Test Vehicles in Flight at Transonic Speeds. NACA RM L8H31a, 1948.

6. Pepper, William B., Jr., and Hoffman, Sherwood: Transonic Flight Tests To Compare the Zero-Lift Drag of Underslung and Symmetrical Nacelles Varied Chordwise at 40 Percent Semispan of a 45° Sweptback, Tapered Wing. NACA RM L50G17a, 1950.

7. Welsh, Clement J., and Morrow, John D.: Effect of Wing-Tank Location on the Drag and Trim of a Swept-Wing Model As Measured in Flight at Transonic Speeds. NACA RM L50A19, 1950.

8. Hoffman, Sherwood, and Mapp, Richard C., Jr.: Transonic Flight Tests To Compare the Zero-Lift Drags of 45° Sweptback Wings of Aspect Ratio 3.55 and 6.0 With and Without Nacelles at the Wing Tips. NACA RM L51L27, 1952.

9. Madden, Robert T., and Kremzier, Emil J.: Data Presentation of Force Characteristics of Several Engine-Strut-Body Configurations at Mach Numbers of 1.8 and 2.0. NACA RM E51E29, 1951.

10. Hasel, Lowell E., and Sevier, John R., Jr.: Aerodynamic Characteristics at Supersonic Speeds of a Series of Wing-Body Combinations Having Cambered Wings With an Aspect Ratio of 3.5 and a Taper Ratio of 0.2. Effect at M = 1.60 of Nacelle Shape and Position on the Aerodynamic Characteristics in Pitch of Two Wing-Body Combinations With 47° Sweptback Wings. NACA RM L51K14a, 1952.

11. May, Ellery B., Jr.: Investigation of Aerodynamic Effects of an External Store in Combination With 60° Delta and Low-Aspect-Ratio Tapered Wings at a Mach Number of 1.9. NACA RM L50K03, 1951.

12. Jacobsen, Carl R.: Effects of Systematically Varying the Spanwise and Vertical Location of an External Store on the Aerodynamic Characteristics of an Unswept Tapered Wing of Aspect Ratio 4 at Mach Numbers of 1.41, 1.62, and 1.96. NACA RM L52F13, 1952.

13. Jacobsen, Carl R.: Effects of the Spanwise, Chordwise, and Vertical Location of an External Store on the Aerodynamic Characteristics of a 60° Delta Wing at Mach Numbers of 1.41, 1.62, and 1.96. NACA RM L52H29, 1952.

14. Jacobsen, Carl R.: Effects of the Spanwise, Chordwise, and Vertical Location of an External Store on the Aerodynamic Characteristics of a 45° Sweptback Tapered Wing of Aspect Ratio 4 at Mach Numbers of 1.41, 1.62, and 1.96. NACA RM L52J27, 1952.

15. Burgess, Warren C., Jr., and Seashore, Ferris L.: Criterions for Condensation-Free Flow in Supersonic Tunnels. NACA TN 2518, 1951.

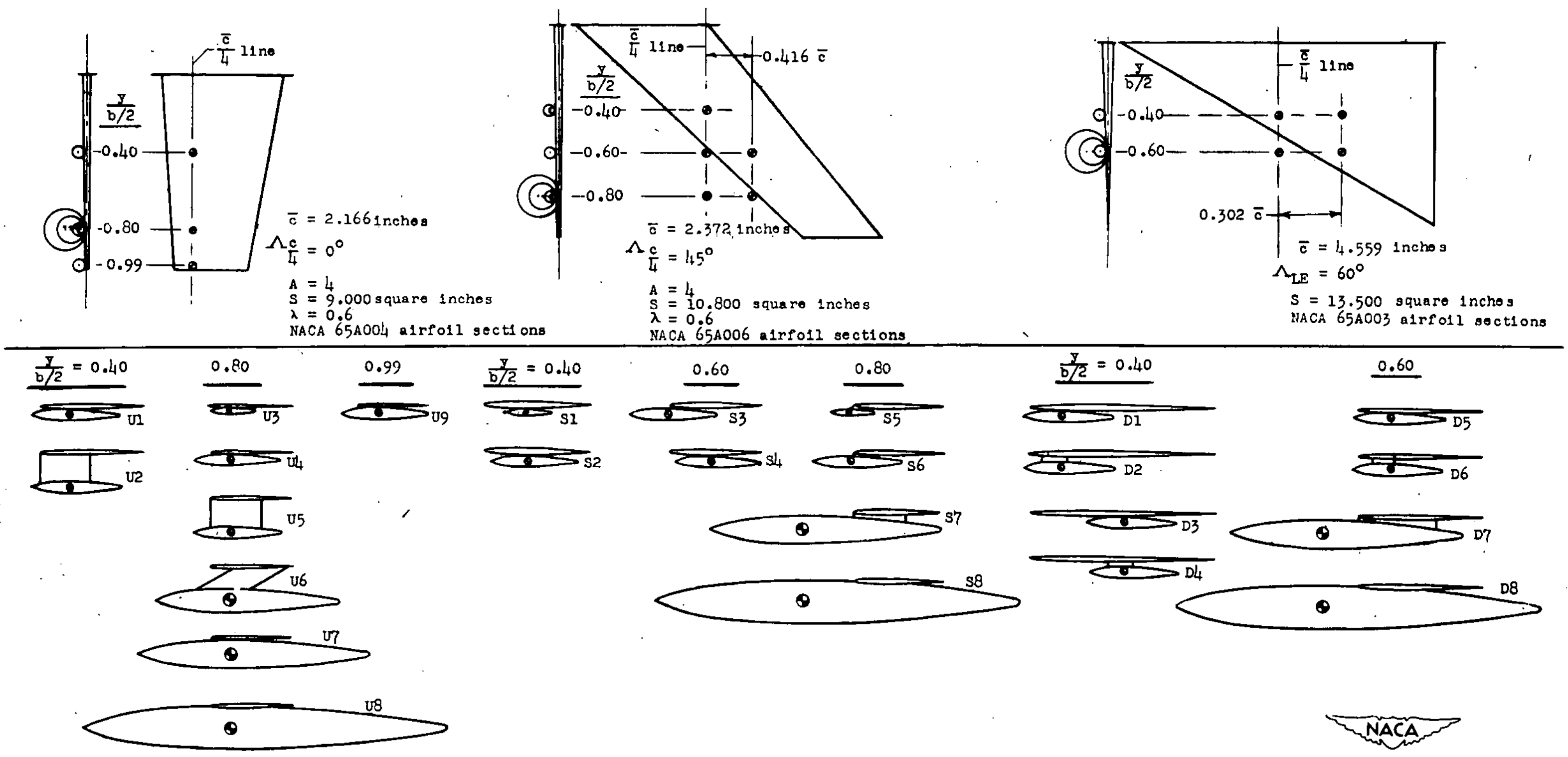
16. May, Ellery B., Jr.: Investigation of the Effects of Leading-Edge Chord-Extensions on the Aerodynamic and Control Characteristics of Two Sweptback Wings at Mach Numbers of 1.41, 1.62, and 1.96. NACA RM L50L06a, 1951.

17. Conner, D. William: Aerodynamic Characteristics of Two All-Movable Wings Tested in the Presence of a Fuselage at a Mach Number of 1.9. NACA RM L8H04, 1948.

TABLE I

REYNOLDS NUMBERS AND AVERAGE DYNAMIC PRESSURES

Wing model	Unswept			Swept 45°			60° Delta		
Average Mach number / Variables	1.41	1.62	1.96	1.41	1.62	1.96	1.41	1.62	1.96
Average dynamic pressure, lb/sq in.	12.0	11.4	10.2	11.9	11.4	10.6	12.0	11.4	10.4
Average Reynolds number	1.4×10^6	1.2×10^6	1.1×10^6	1.5×10^6	1.4×10^6	1.3×10^6	2.8×10^6	2.6×10^6	2.4×10^6



Unswept Wing (U):

$\frac{y}{b/2}$	$\frac{l}{l_{basic}}$	$\frac{x}{c}$	$\frac{z}{d}$	Key
0.40	0.50	0	0.50	U1
0.80	0.50	0	3.00	U2
	0.25	0	0.50	U3
	0.50	0	0.50	U4
	0.50	0	3.00	U5
	1.00	0	1.50	U6
	1.26	0	0.50	U7
	2.00	0	0.46	U8
0.99	0.50	0	0.50	U9

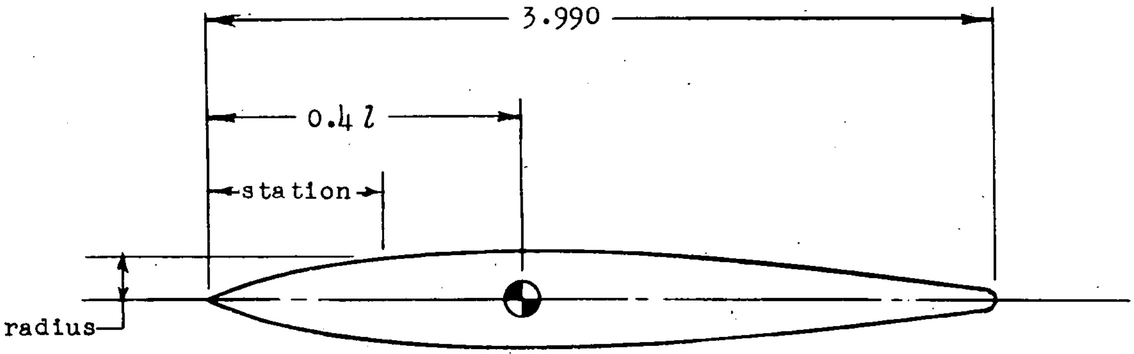
45° Sweptback Wing (S):

$\frac{y}{b/2}$	$\frac{l}{l_{basic}}$	$\frac{x}{c}$	$\frac{z}{d}$	Key
0.40	0.25	0	0.50	S1
	0.50	0	0.50	S2
0.60	0.50	0	0.50	S3
	0.50	0.416	0.50	S4
0.80	0.25	0.416	0.50	S5
	0.50	0.416	0.50	S6
	1.26	0	0.50	S7
	2.00	0	0.44	S8

Delta Wing (D):

$\frac{y}{b/2}$	$\frac{l}{l_{basic}}$	$\frac{x}{c}$	$\frac{z}{d}$	Key
0.40	0.50	0	0.50	D1
	0.50	0	1.00	D2
	0.50	0.302	0.50	D3
	0.50	0.302	1.00	D4
0.60	0.50	0.302	0.50	D5
	0.50	0.302	1.00	D6
	1.26	0	0.50	D7
	2.00	0	0.46	D8

Figure 1.- Locations at which various size Douglas Aircraft Company, Inc. stores were tested on three wing configurations.



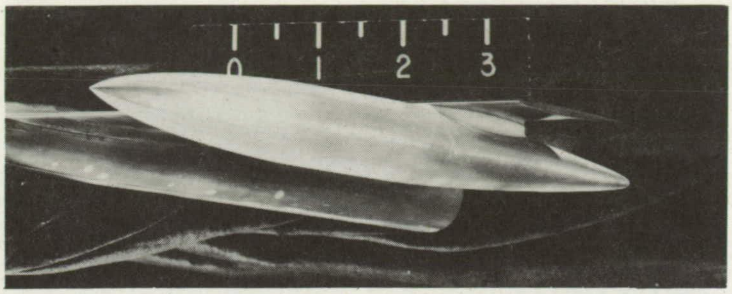
DAC store

Fineness ratio = 8.58

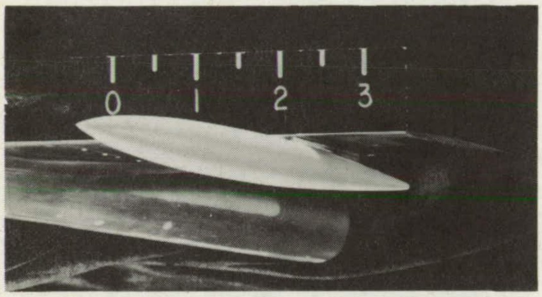
(Ratio of volume to diameter cubed $\frac{V}{d^3} \approx 4$)

DAC Store Coordinates	
station	radius
0	0
0.076	0.036
.188	.080
.299	.116
.411	.140
.519	.160
.630	.176
.742	.188
.966	.211
1.185	.227
1.408	.233
1.983	.233
2.206	.229
2.426	.219
2.645	.203
2.873	.184
3.204	.148
3.423	.120
3.647	.088
3.910	.048
3.990	0
T.E.R.	.022

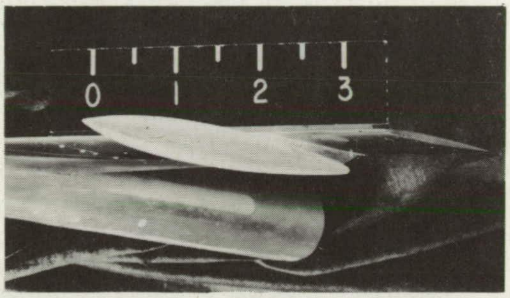
Figure 2.- Details of Douglas Aircraft Company, Inc. 414-gallon-size external store. All dimensions are in inches.



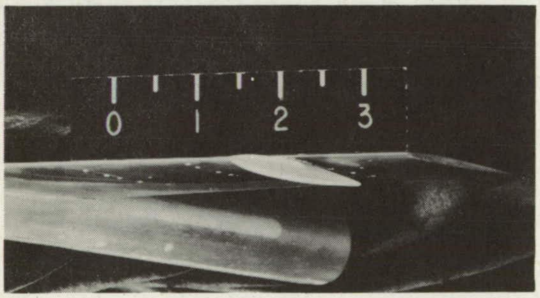
$\frac{l}{l_{basic}} = 2.00$



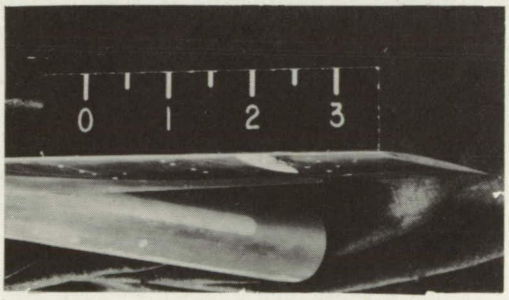
$\frac{l}{l_{basic}} = 1.26$



$\frac{l}{l_{basic}} = 1.00$



$\frac{l}{l_{basic}} = 0.50$



$\frac{l}{l_{basic}} = 0.25$

Figure 3.- Photographs of the Douglas Aircraft Company, Inc. stores mounted on the 45° swept wing.

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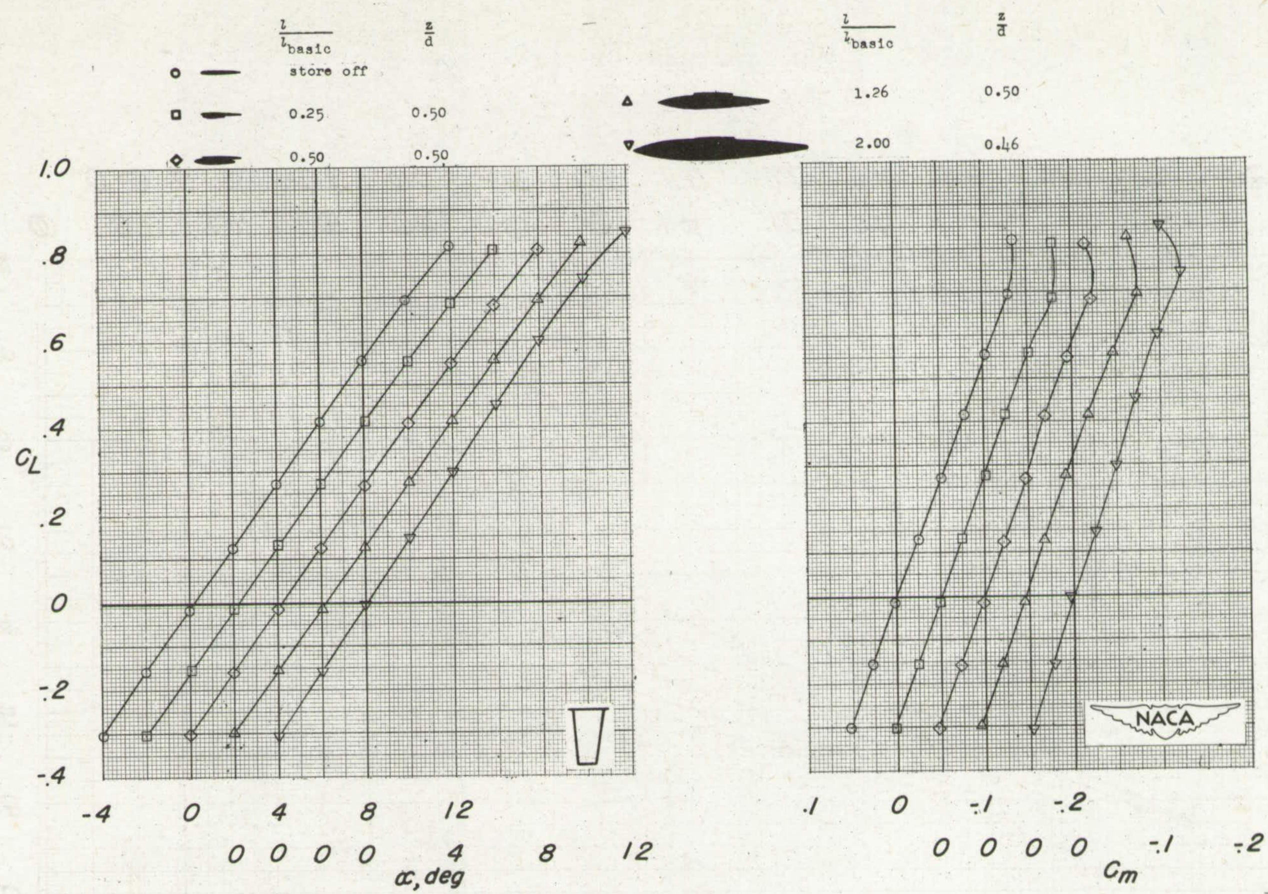
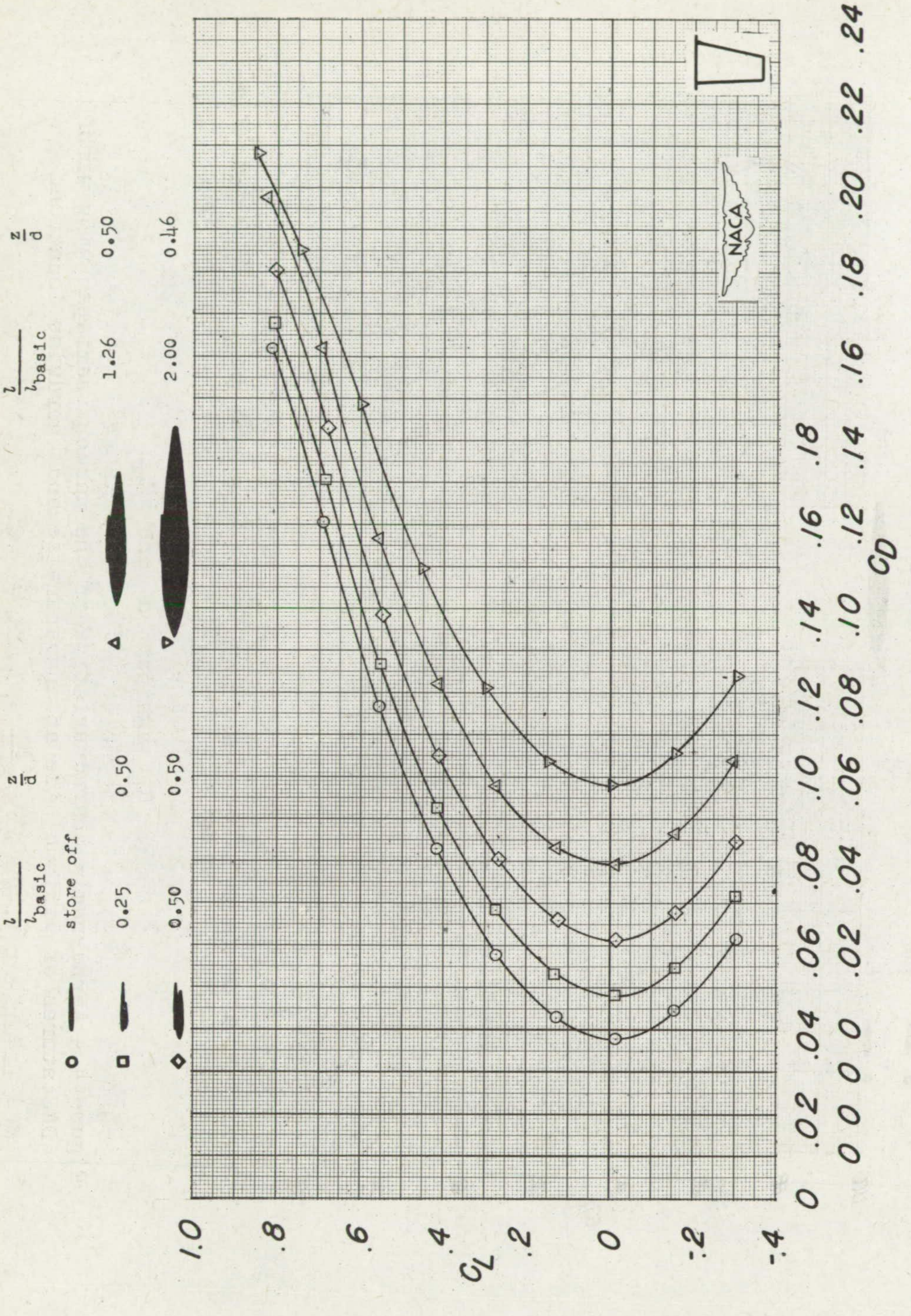


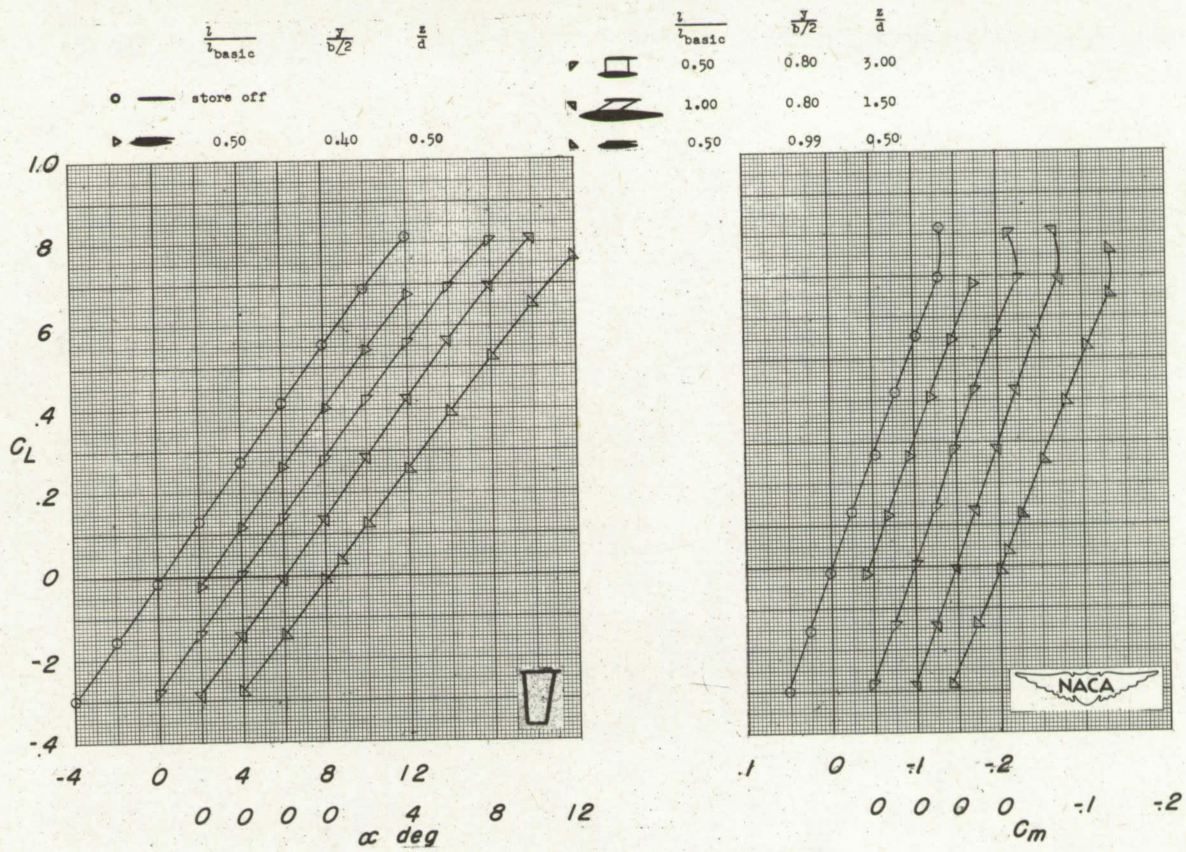
(a) C_L against α and C_m.

Figure 4.- Aerodynamic characteristics of the unswept semispan wing with DAC stores of various size at one spanwise and chordwise location. $M = 1.41$; $R \approx 1.4 \times 10^6$; $\frac{y}{b/2} = 0.80$; $\frac{x}{c} = 0$.



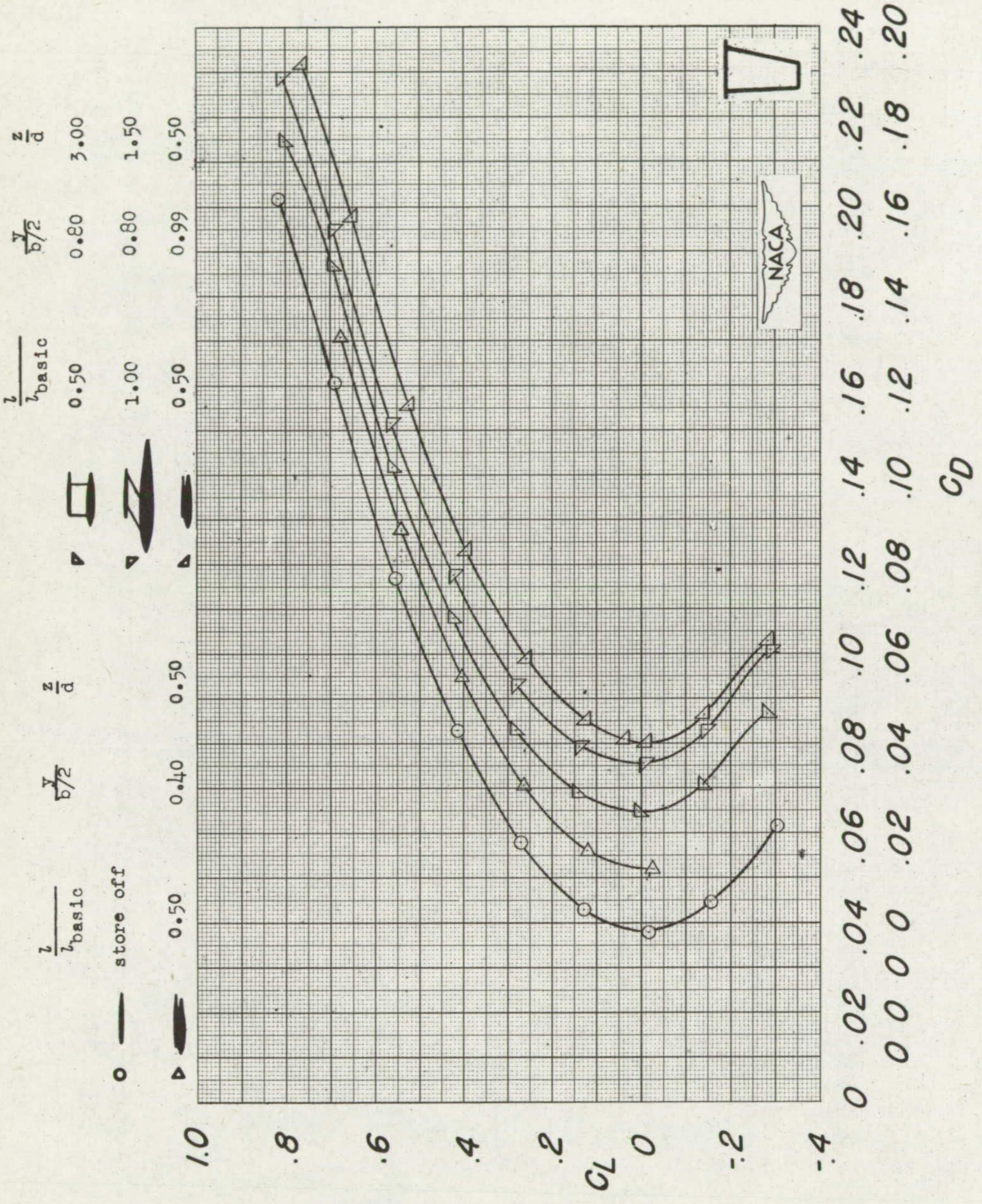
(b) C_L against C_D.

Figure 4.- Concluded.



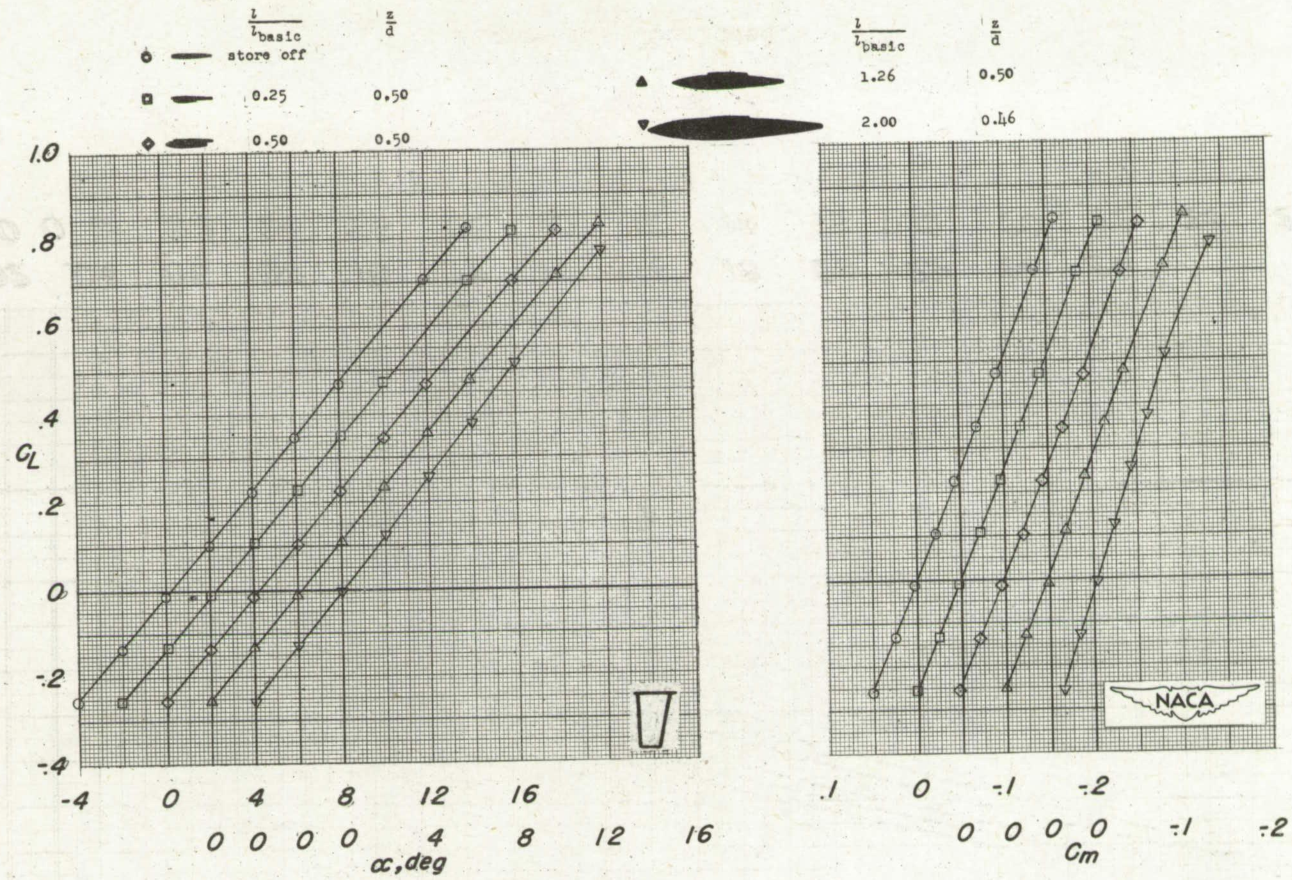
(a) C_L against α and C_m.

Figure 5.- Aerodynamic characteristics of the unswept semispan wing with DAC stores of various size at several spanwise locations and with one store mounted on a swept set-back strut. $M = 1.41$; $R \approx 1.4 \times 10^6$; $\frac{x}{c} = 0$.



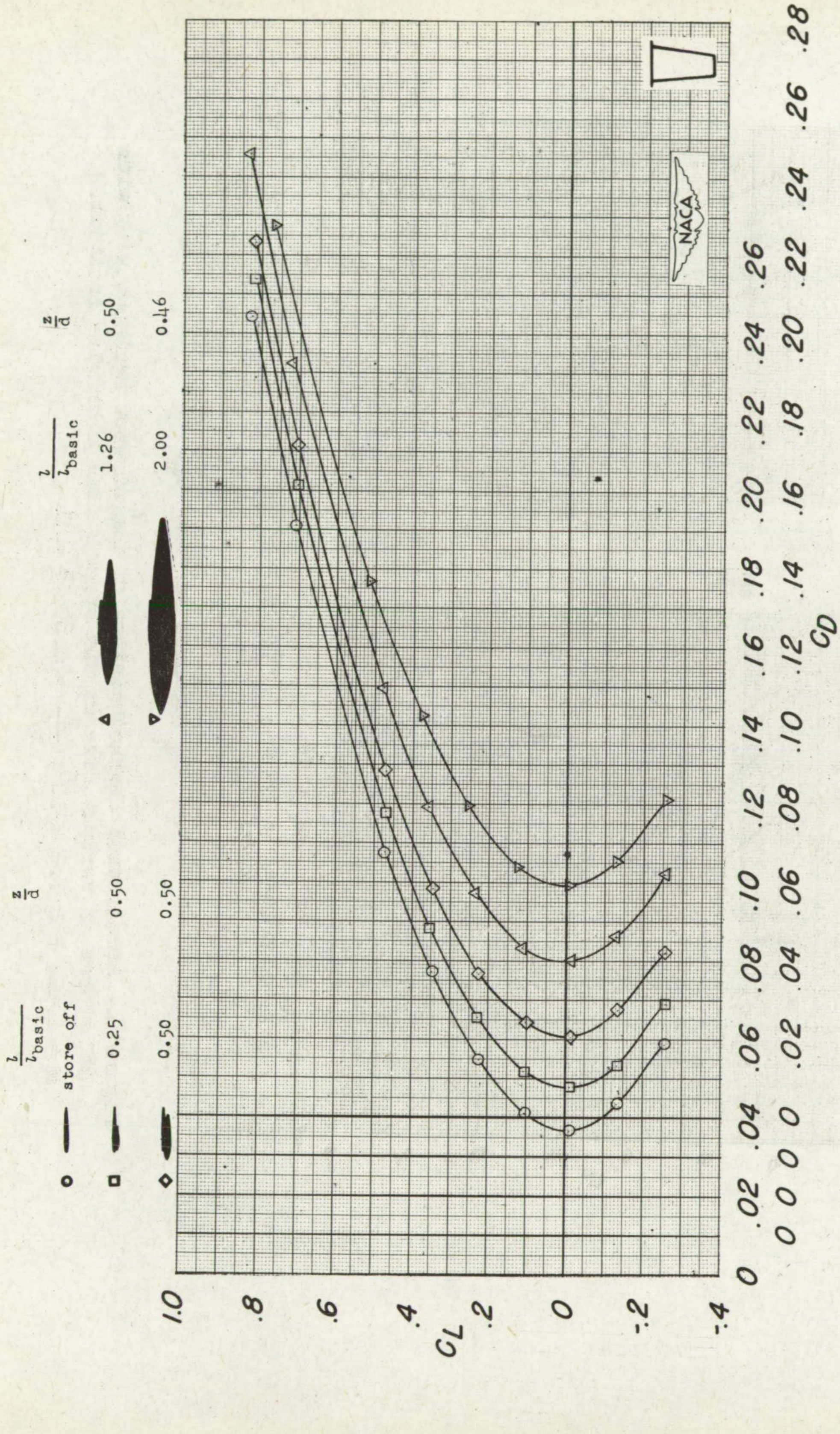
(b) C_L against C_D.

Figure 5.- Concluded.



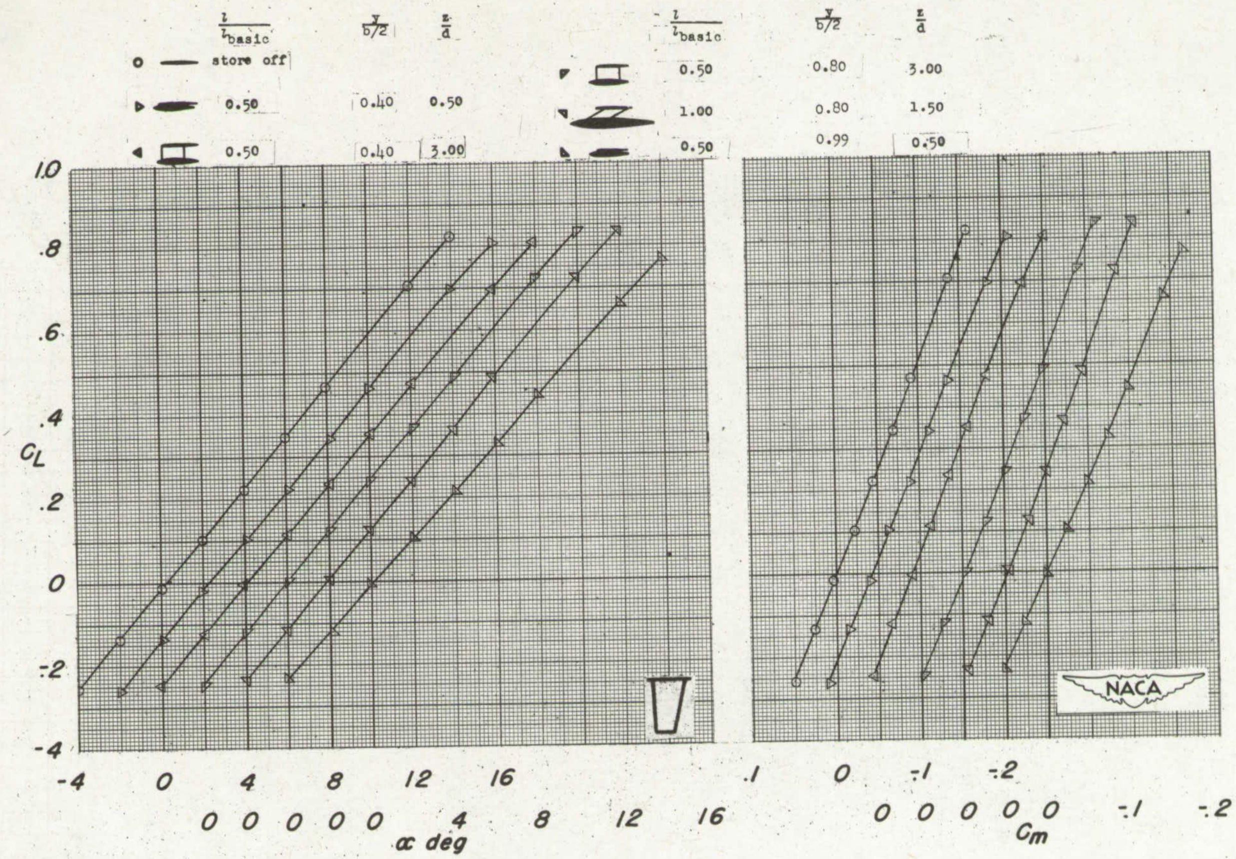
(a) C_L against α and C_m.

Figure 6.- Aerodynamic characteristics of the unswept semispan wing with DAC stores of various size at one spanwise and chordwise location. $M = 1.62$; $R \approx 1.2 \times 10^6$; $\frac{y}{b/2} = 0.80$; $\frac{x}{c} = 0$.



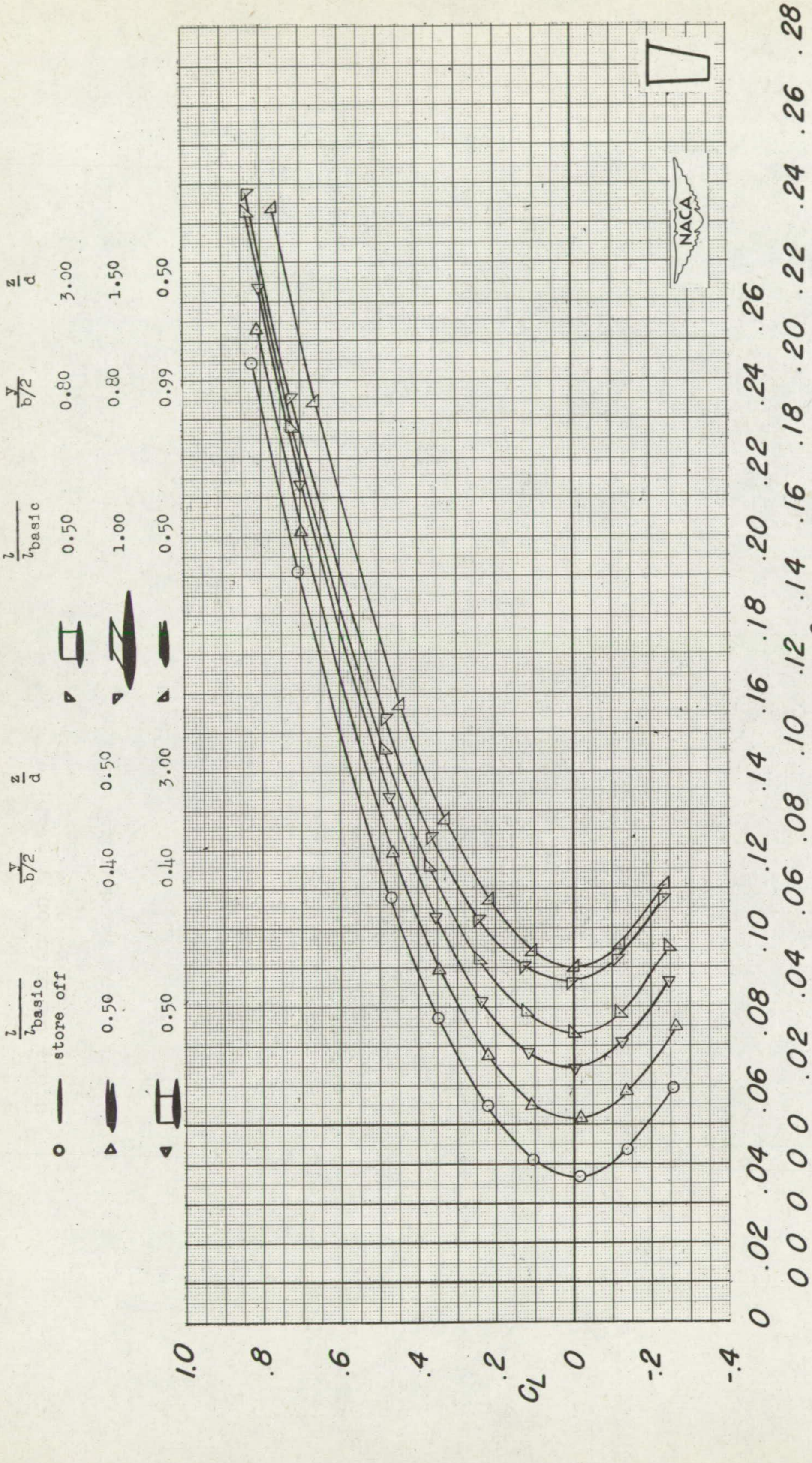
(b) C_L against C_D.

Figure 6.- Concluded.



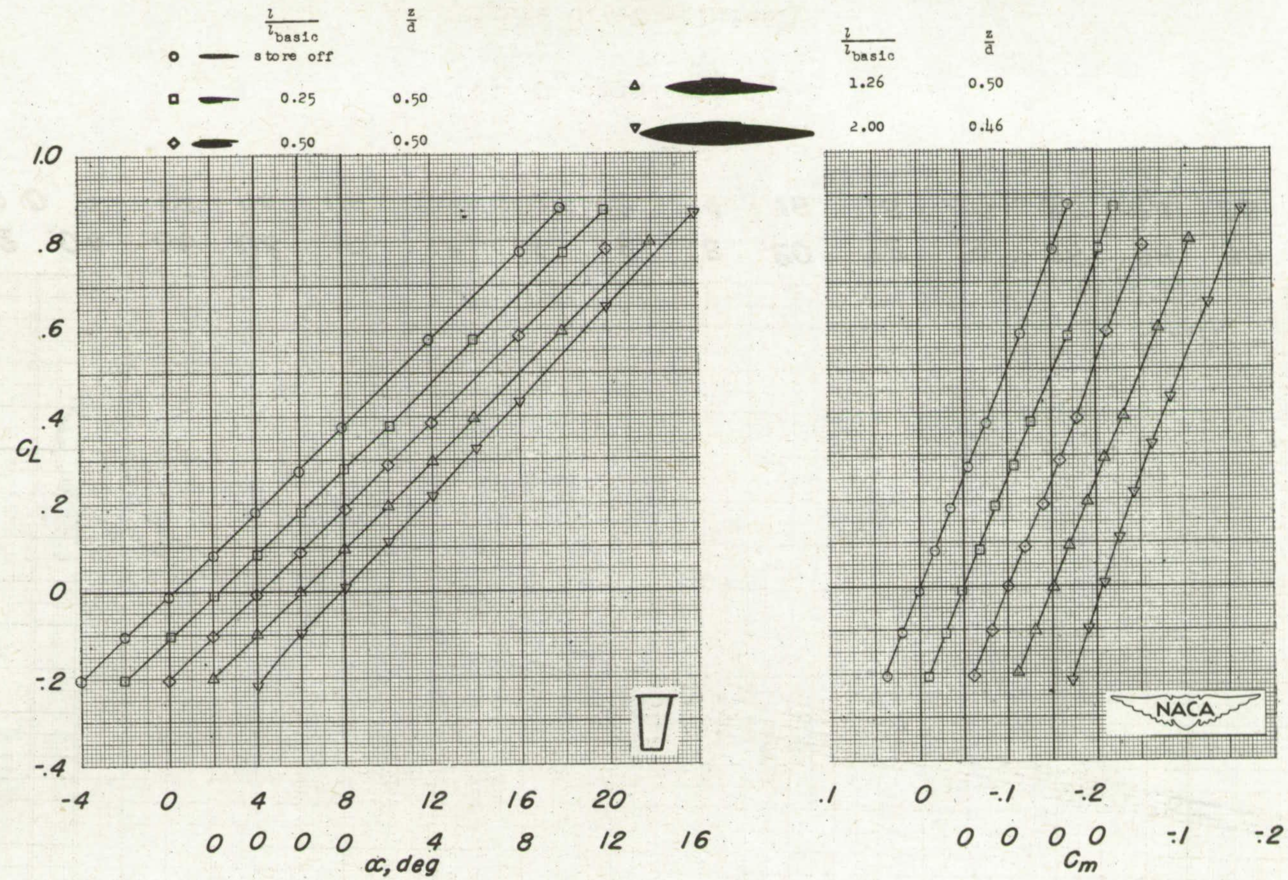
(a) C_L against α and C_m.

Figure 7.- Aerodynamic characteristics of the unswept semispan wing with DAC stores of various size at several spanwise locations and with one store mounted on a swept set-back strut. $M = 1.62$; $R \approx 1.2 \times 10^6$; $\frac{x}{c} = 0$.



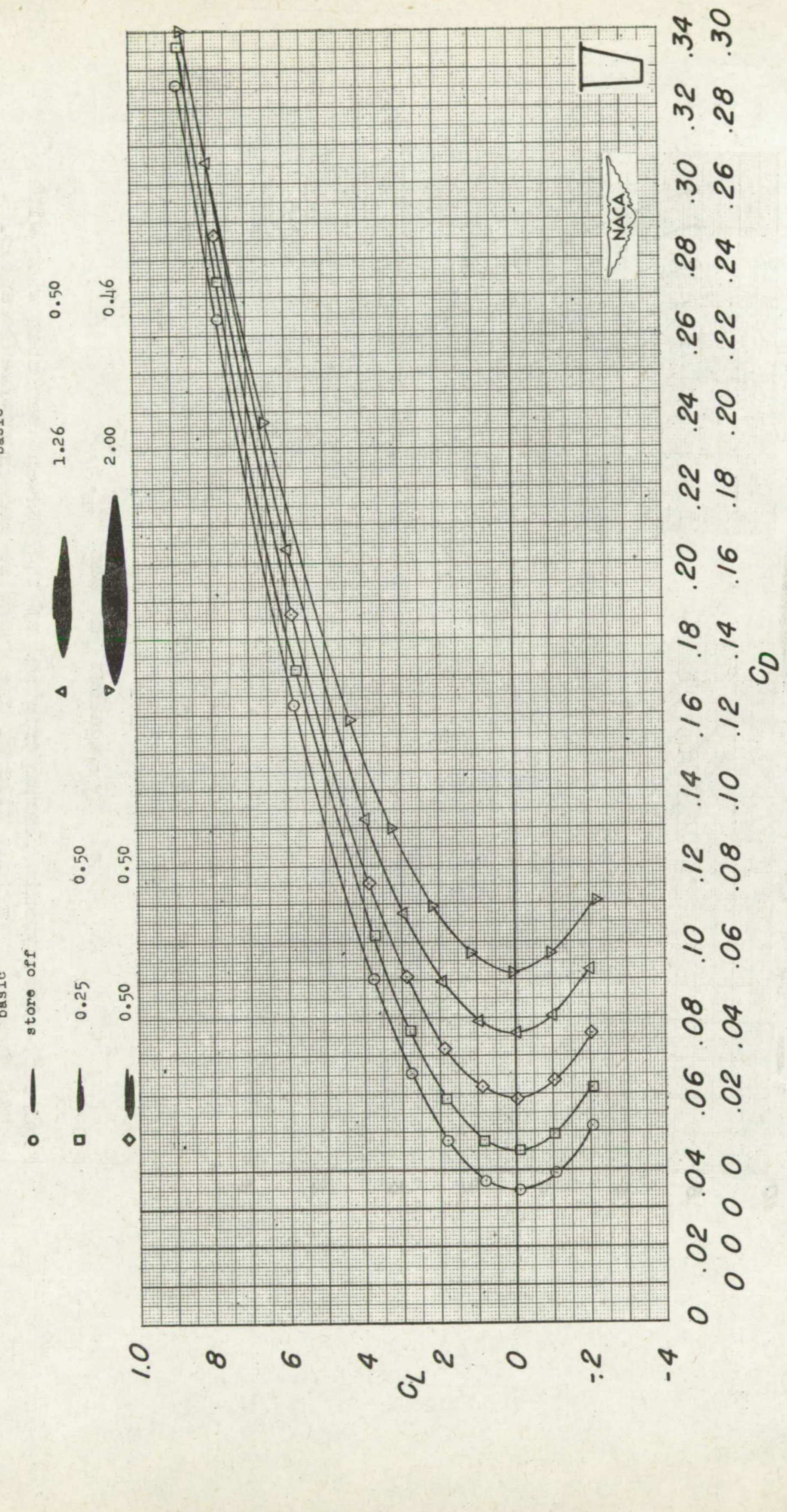
(b) C_L against C_D.

Figure 7.- Concluded.



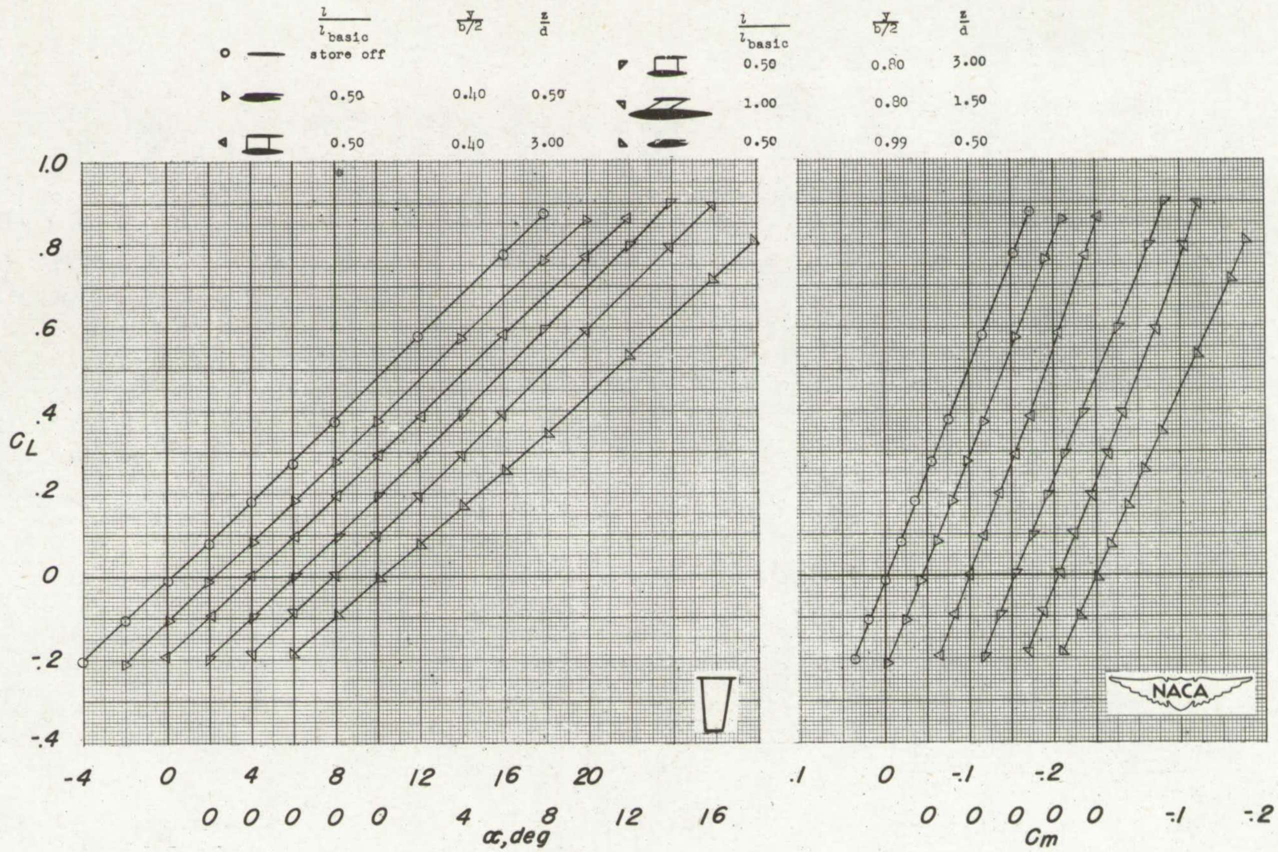
(a) C_L against α and C_m.

Figure 8.- Aerodynamic characteristics of the unswept semispan wing with DAC stores of various size at one spanwise and chordwise location. $M = 1.96$; $R \approx 1.1 \times 10^6$; $\frac{y}{b/2} = 0.80$; $\frac{x}{c} = 0$.



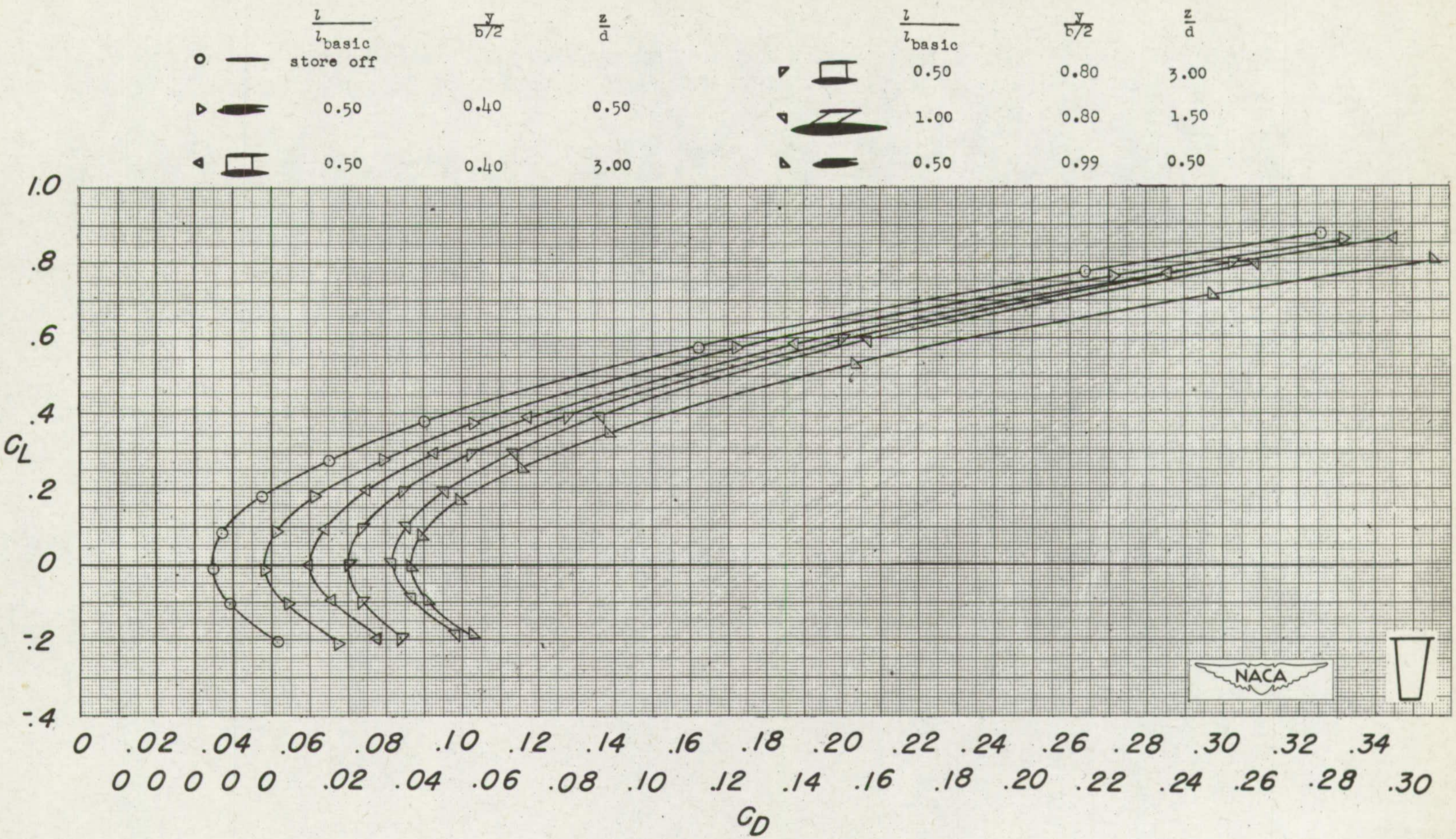
(b) C_L against C_D.

Figure 8.- Concluded.



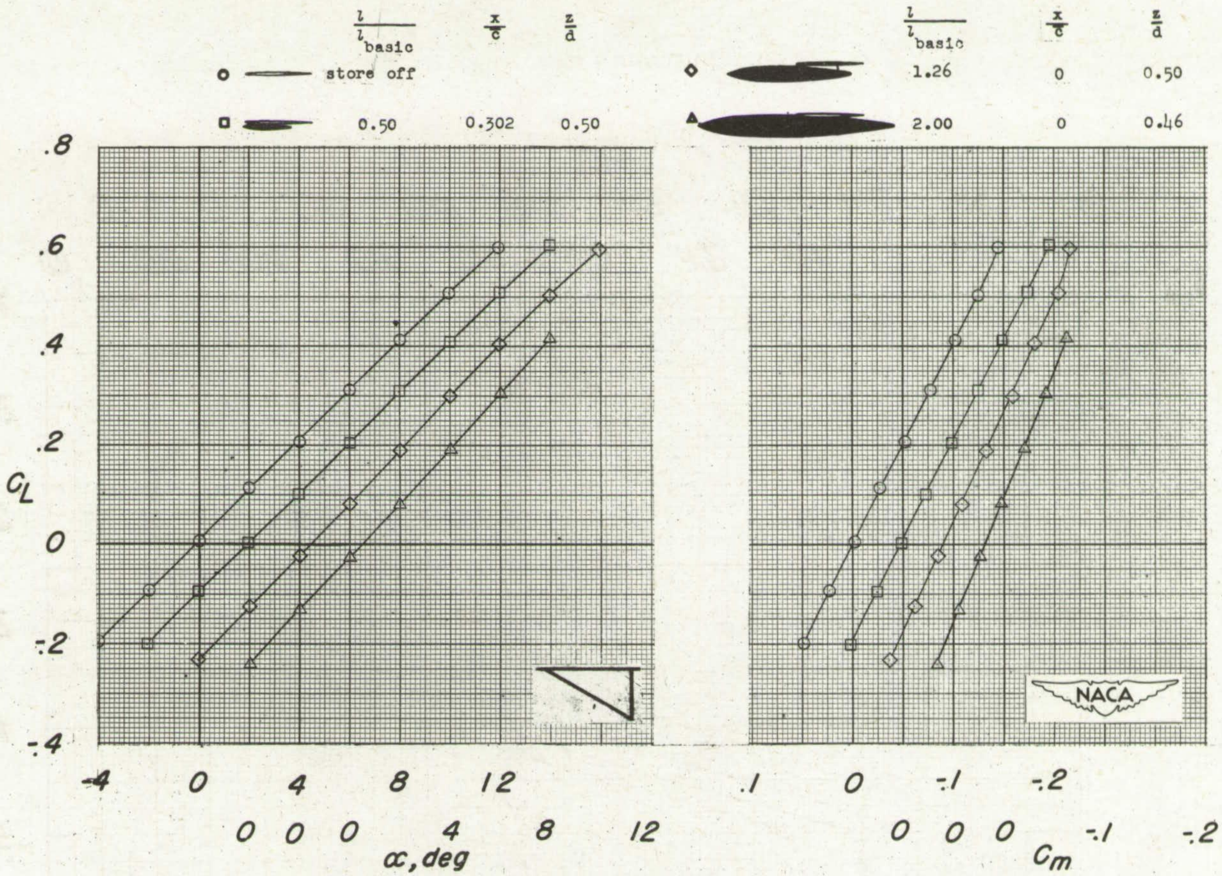
(a) C_L against α and C_m.

Figure 9.- Aerodynamic characteristics of the unswept semispan wing with DAC stores of various size at several spanwise locations and with one store mounted on a swept set-back strut. $M = 1.96$; $R \approx 1.1 \times 10^6$; $\frac{x}{c} = 0$.



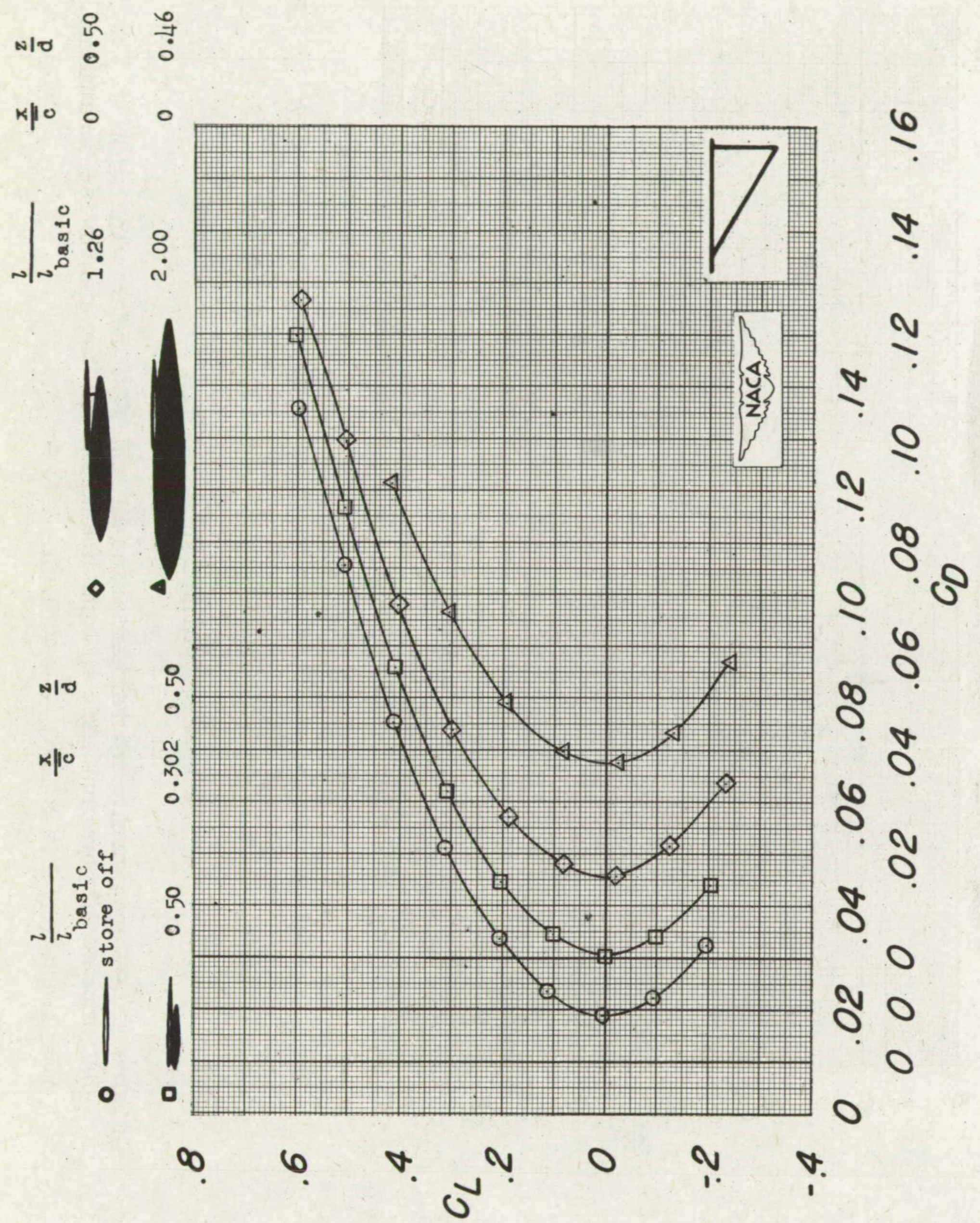
(b) C_L against C_D.

Figure 9.- Concluded.



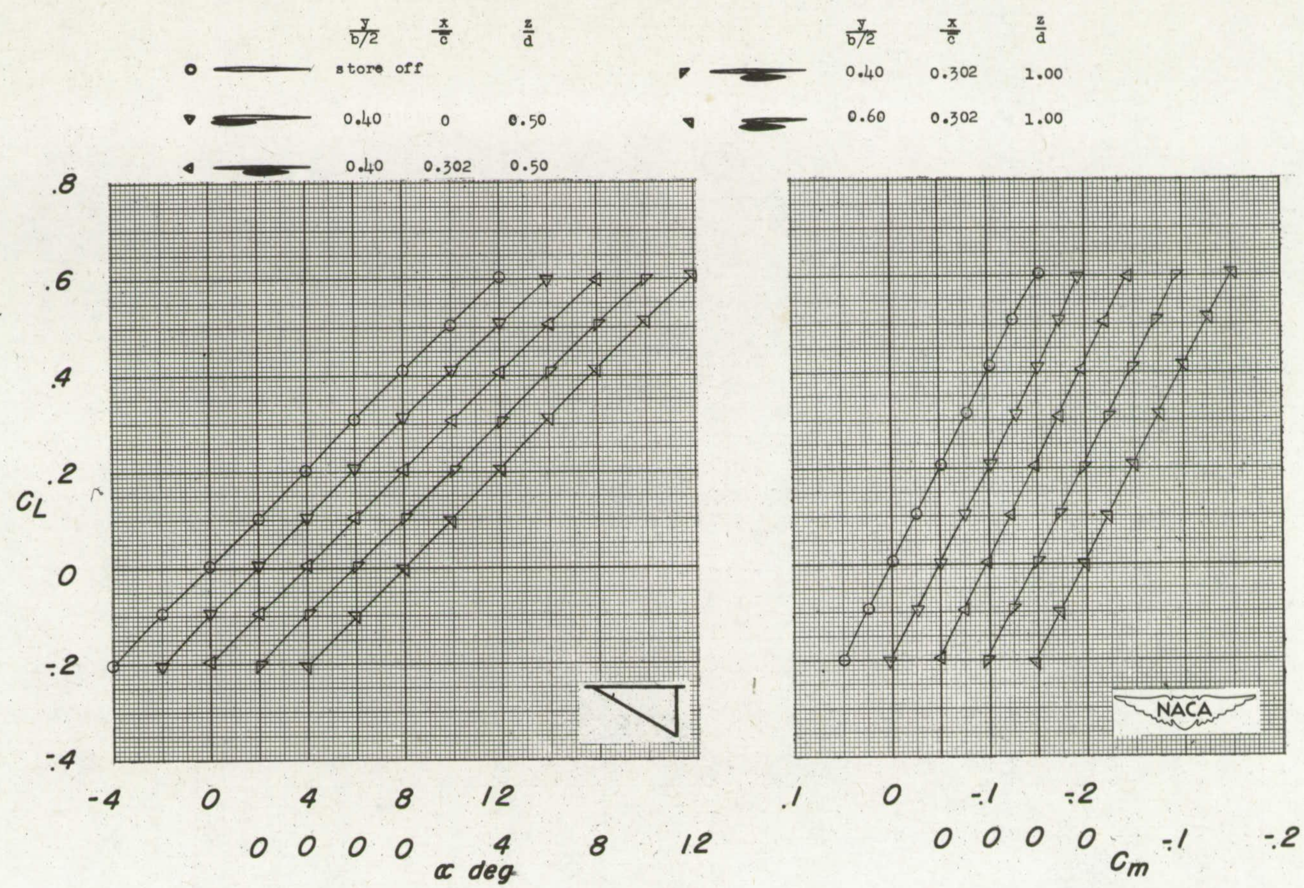
(a) C_L against α and C_m.

Figure 10.- Aerodynamic characteristics of the 60° delta wing with DAC stores of various size at one spanwise and two chordwise locations. $M = 1.41$; $R \approx 2.8 \times 10^6$; $\frac{y}{b/2} = 0.60$.



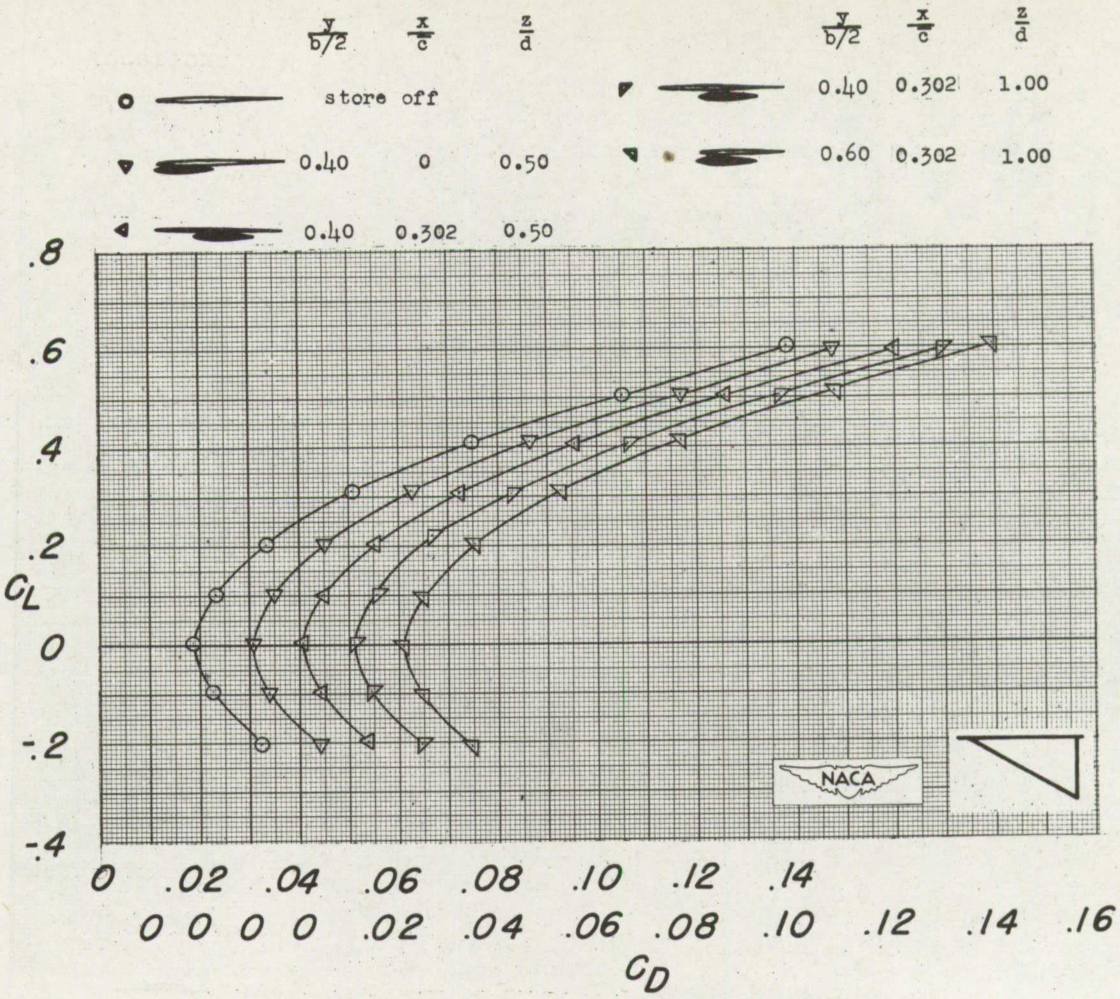
(b) C_L against C_D.

Figure 10.- Concluded.



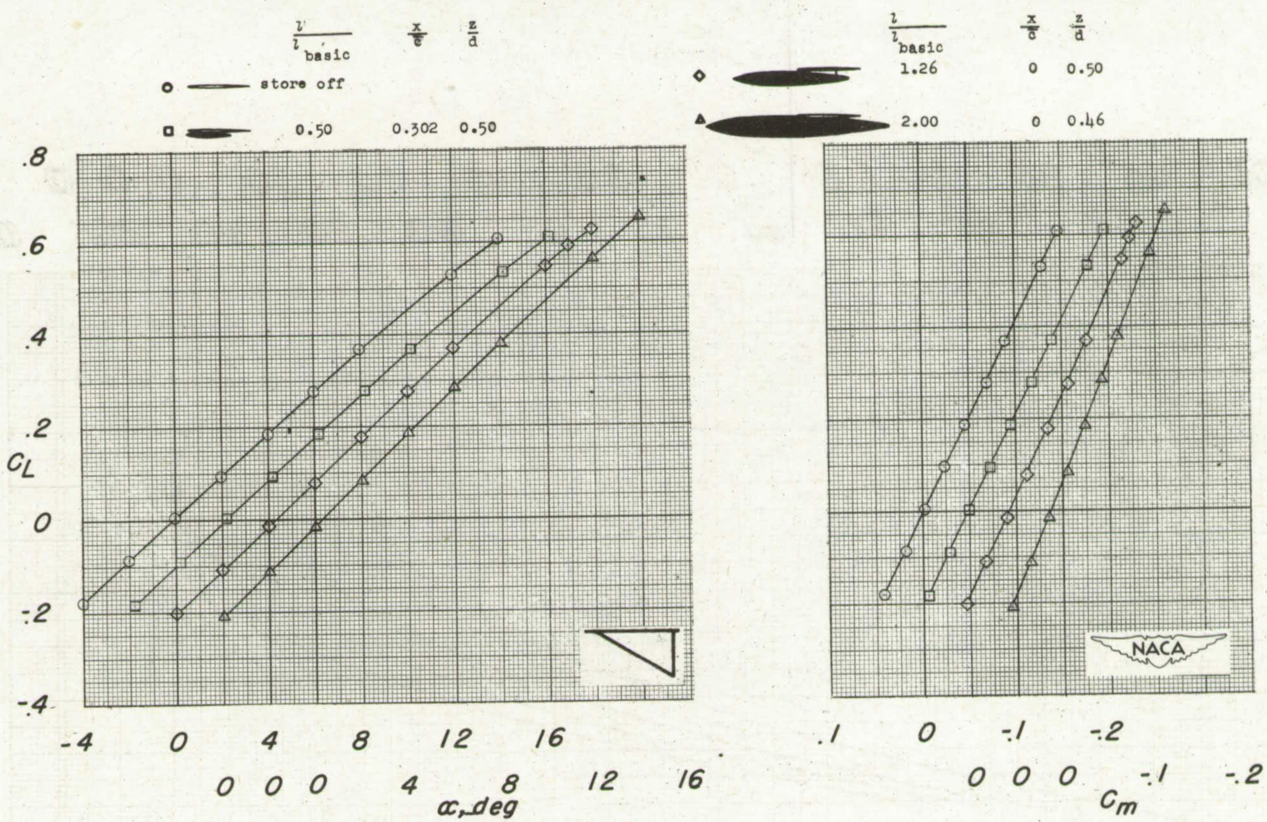
(a) C_L against α and C_m.

Figure 11.- Aerodynamic characteristics of the 60° delta wing with DAC size DAC store at several spanwise, chordwise, and vertical locations. $M = 1.41$; $R \approx 2.8 \times 10^6$; $\frac{l}{l_{basic}} = 0.50$.



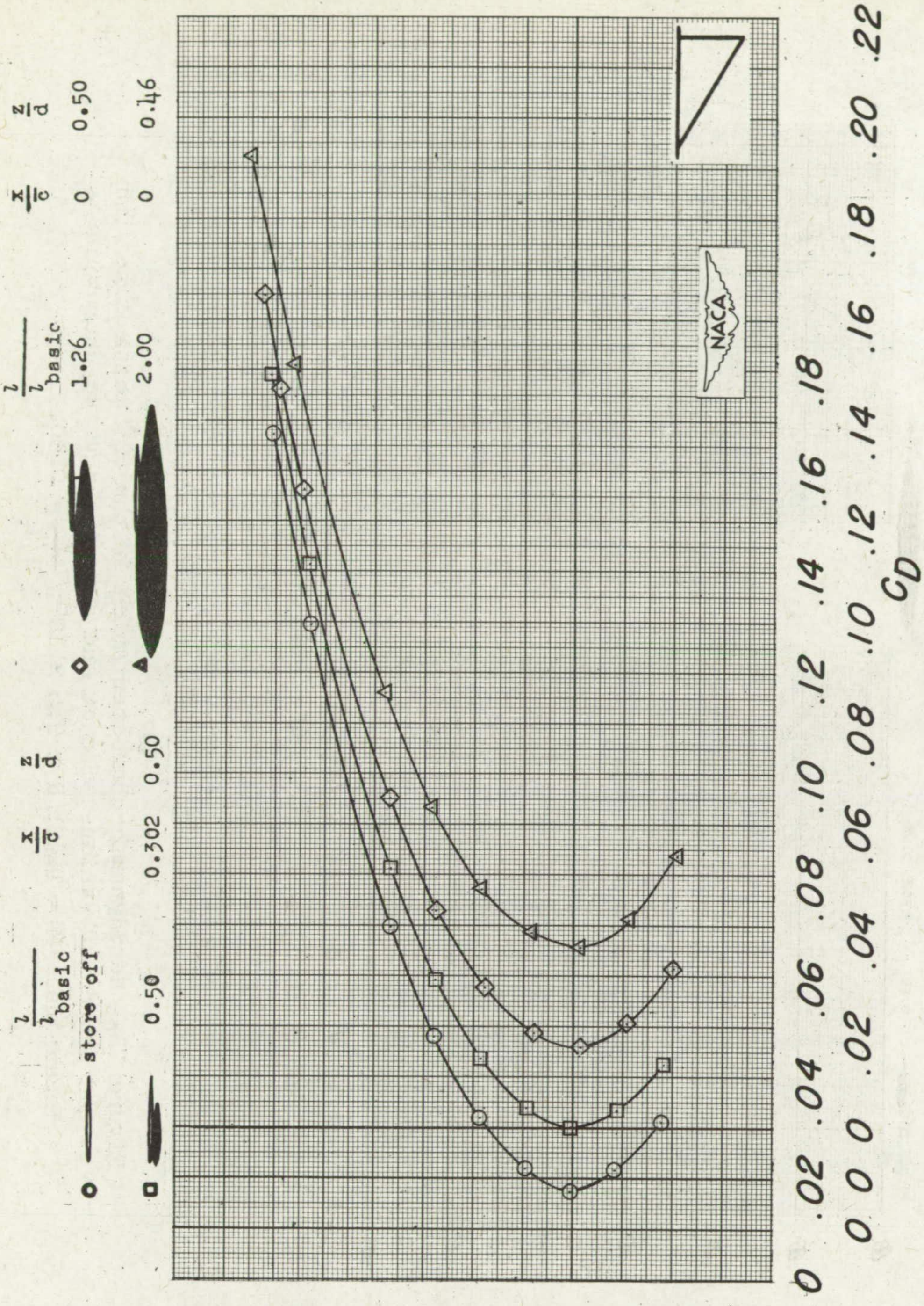
(b) C_L against C_D.

Figure 11.- Concluded.



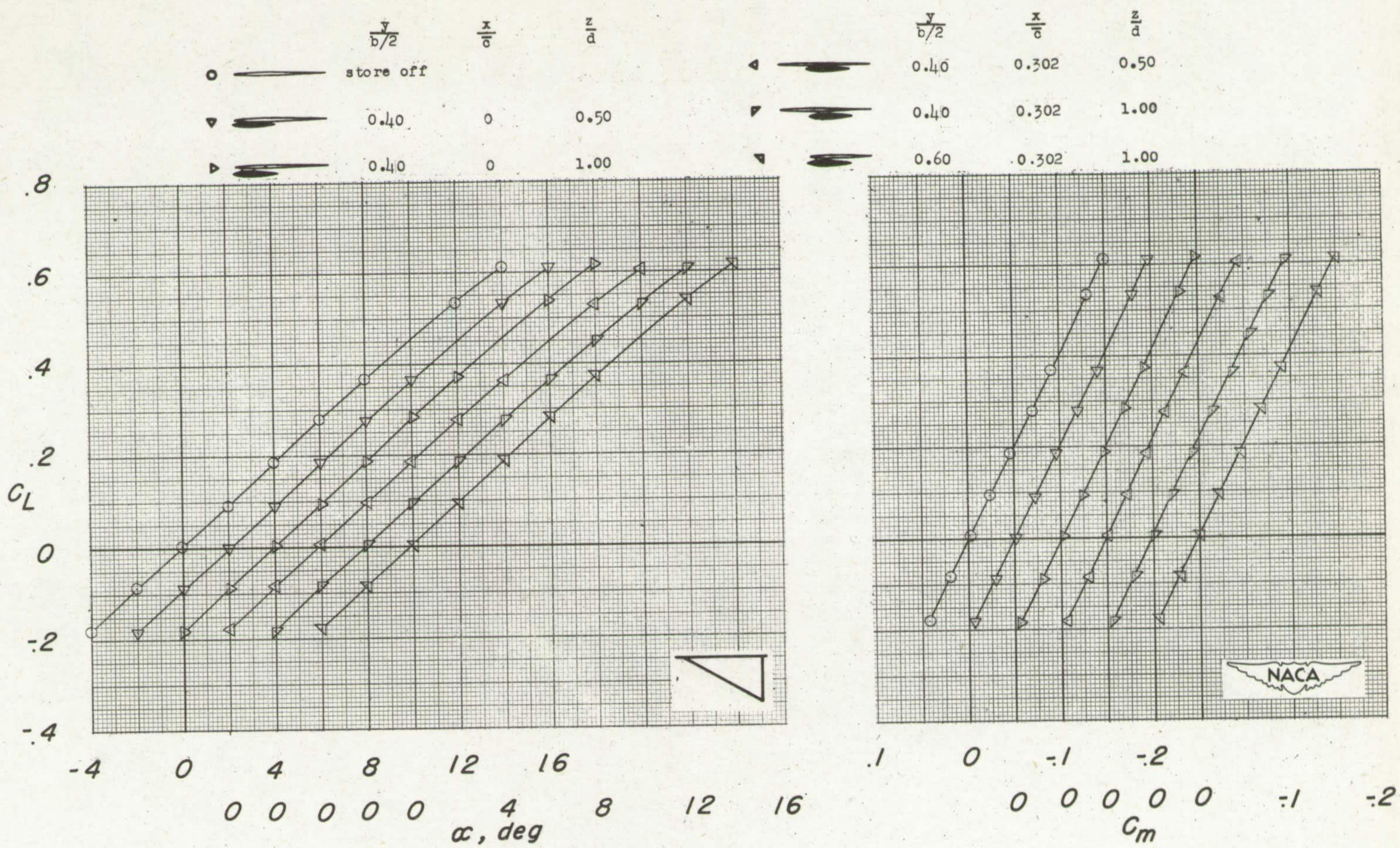
(a) C_L against α and C_m.

Figure 12.- Aerodynamic characteristics of the 60° delta wing with DAC stores of various size at one spanwise and two chordwise locations. $M = 1.62$; $R \approx 2.6 \times 10^6$; $\frac{y}{b/2} = 0.60$.



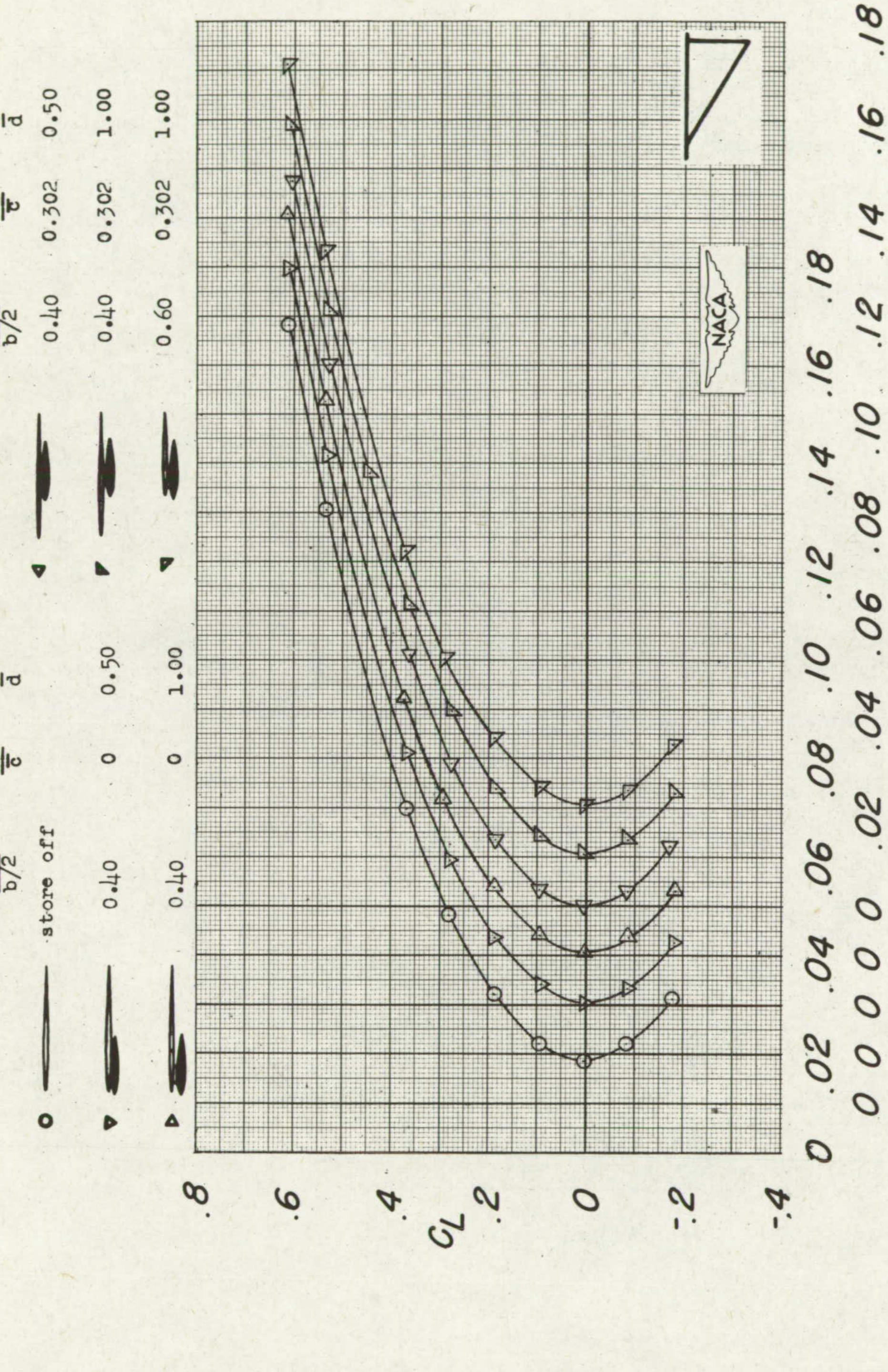
(b) C_L against C_D.

Figure 12.- Concluded.



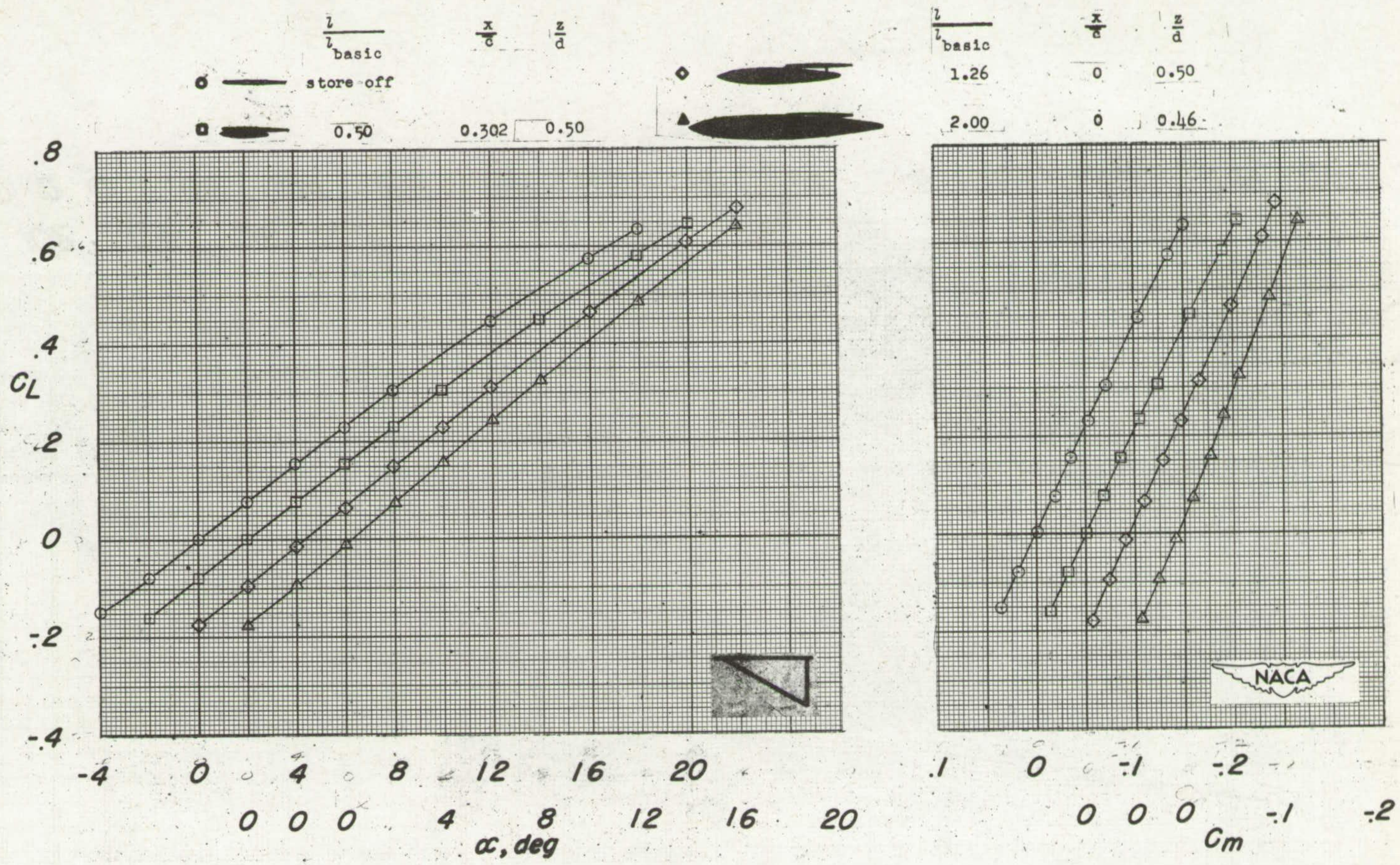
(a) C_L against α and C_m.

Figure 13.- Aerodynamic characteristics of the 60° delta wing with DAC size DAC store at several spanwise, chordwise, and vertical locations. $M = 1.62$; $R \approx 2.6 \times 10^6$; $\frac{l}{l_{basic}} = 0.50$.



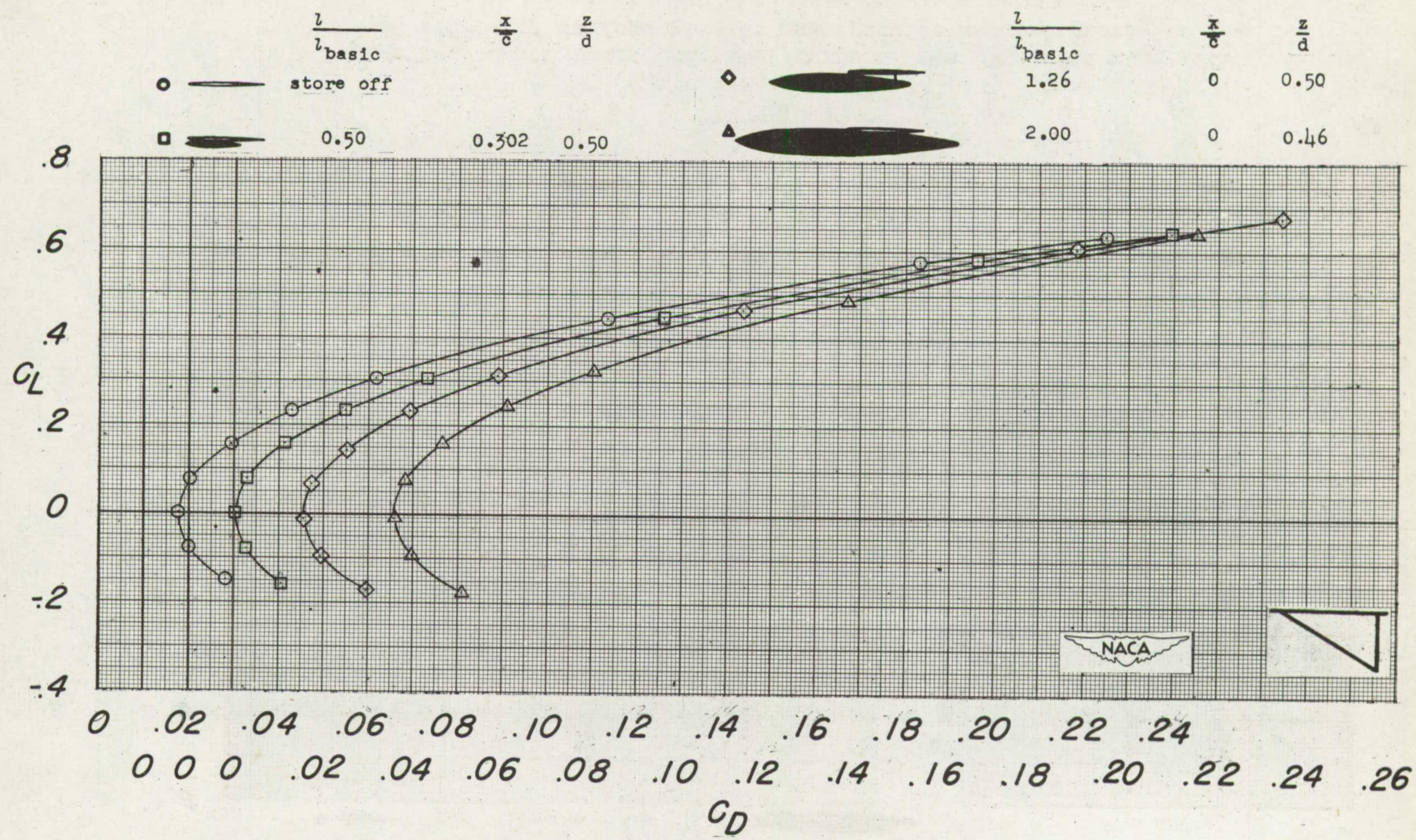
(b) C_L against C_D.

Figure 13.- Concluded.



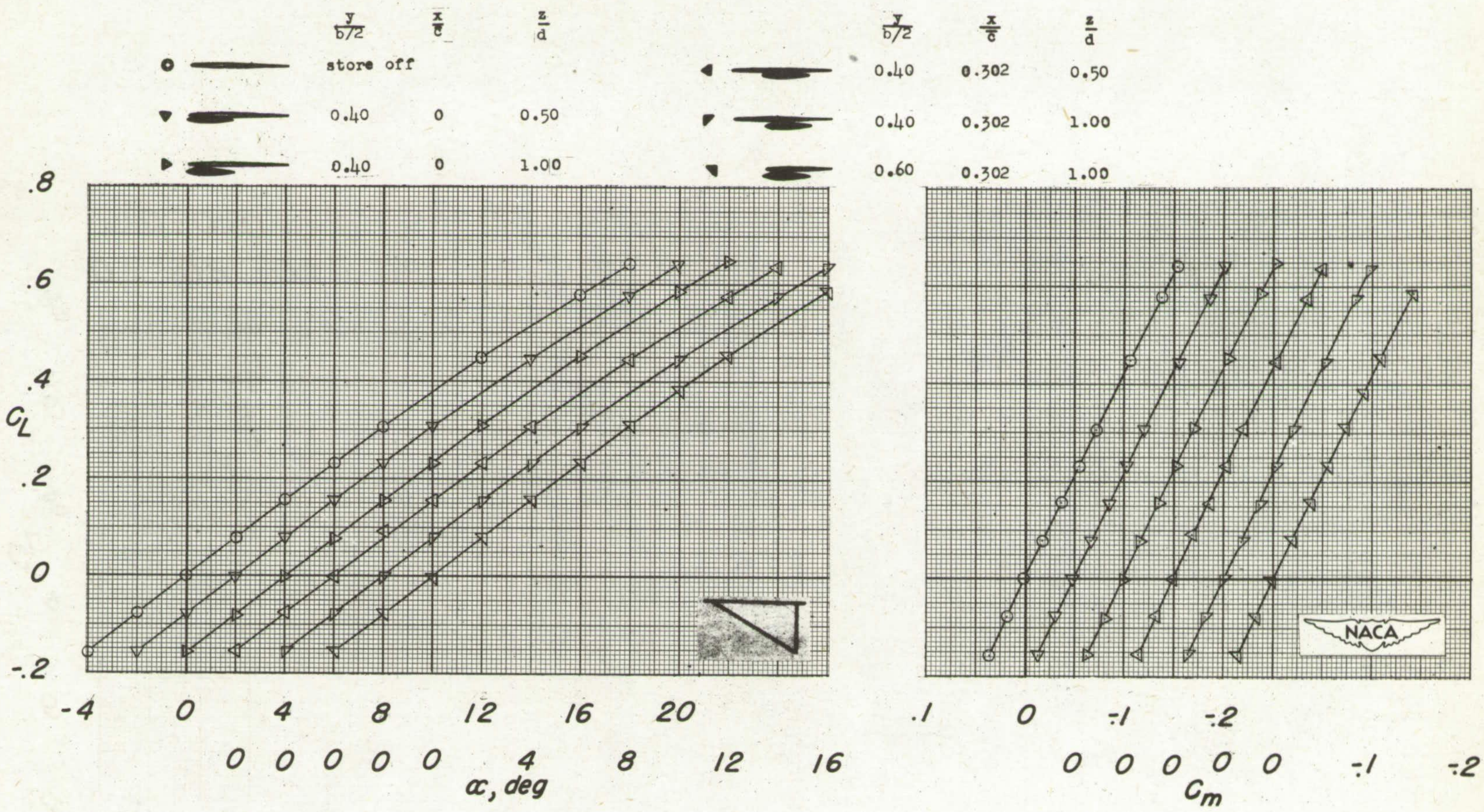
(a) C_L against α and C_m.

Figure 14.- Aerodynamic characteristics of the 60° delta wing with DAC stores of various size at one spanwise and two chordwise locations. $M = 1.96$; $R \approx 2.4 \times 10^6$; $\frac{y}{b/2} = 0.60$.



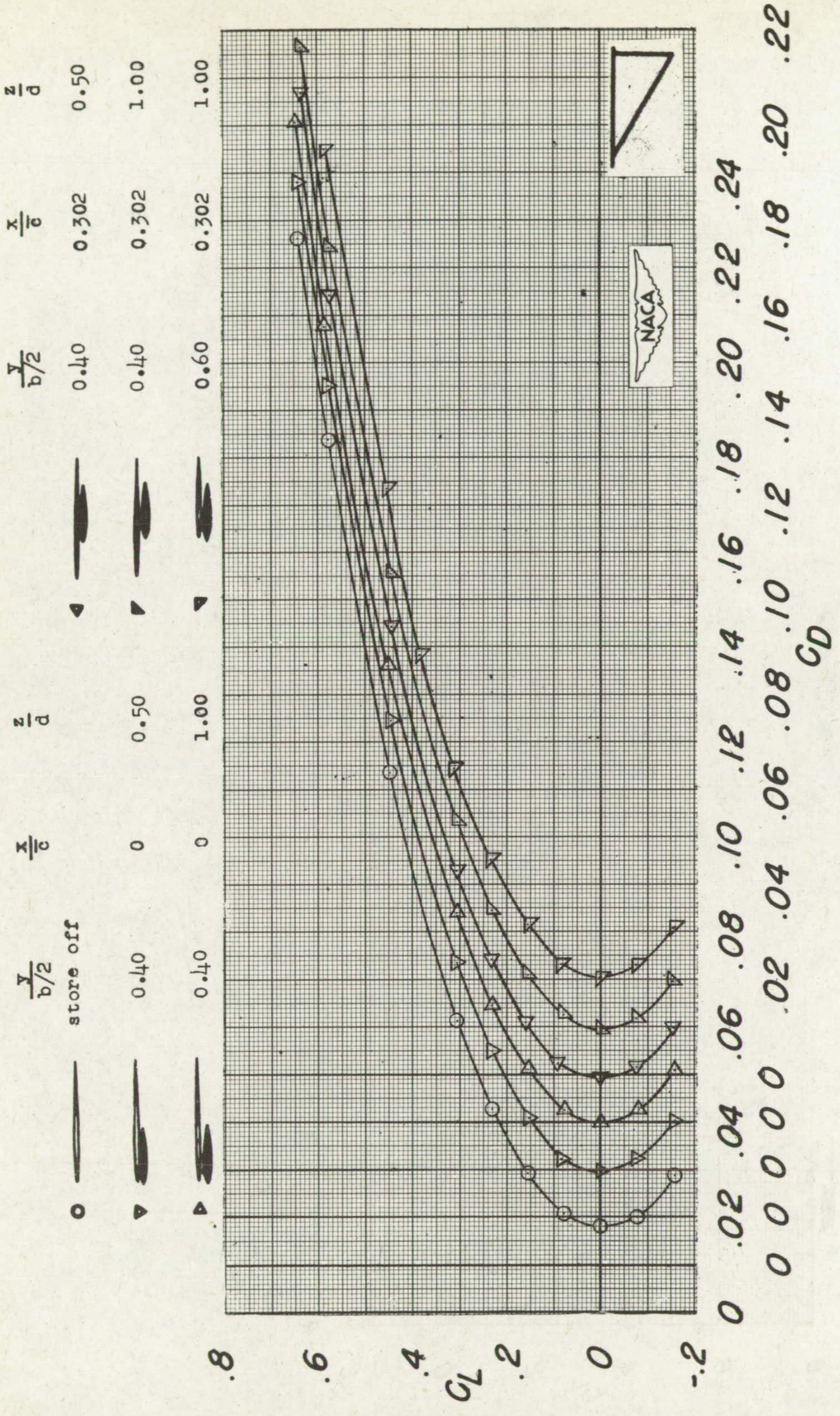
(b) C_L against C_D.

Figure 14.- Concluded.



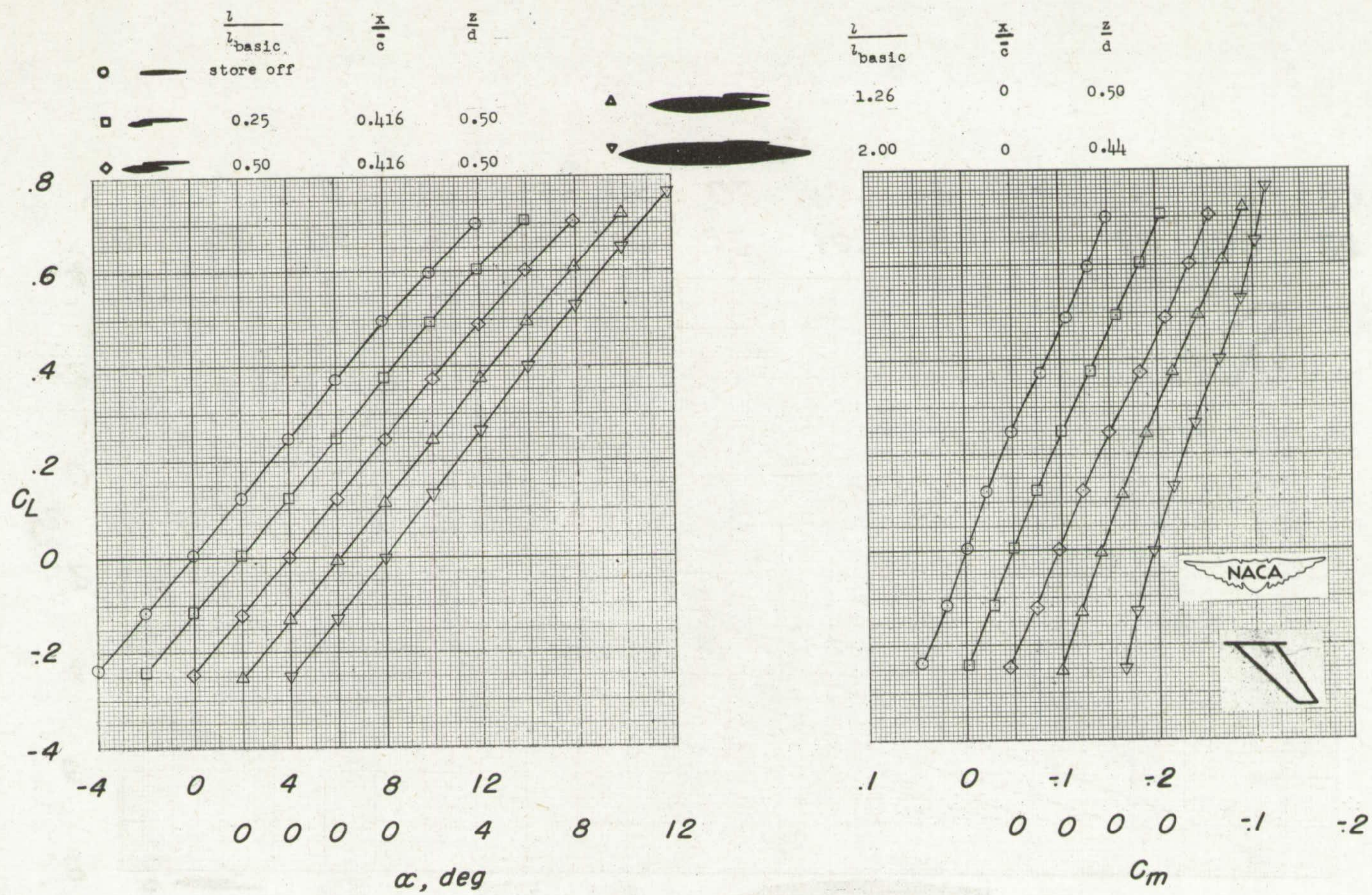
(a) C_L against α and C_m.

Figure 15.- Aerodynamic characteristics of the 60° delta wing with DAC size DAC store at several spanwise, chordwise, and vertical locations. $M = 1.96$; $R \approx 2.4 \times 10^6$; $\frac{l}{l_{basic}} = 0.50$.



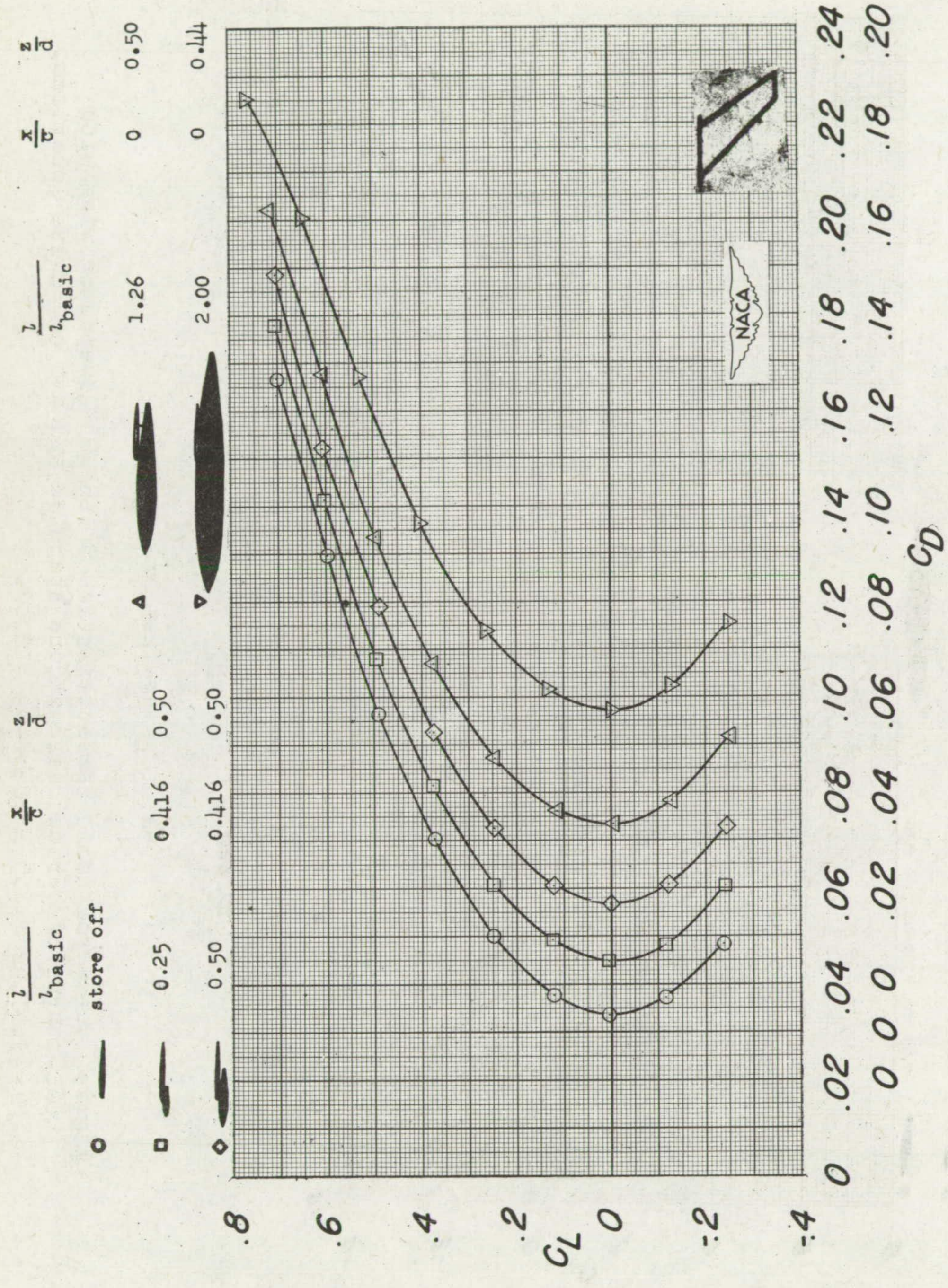
(b) C_L against C_D.

Figure 15.- Concluded.



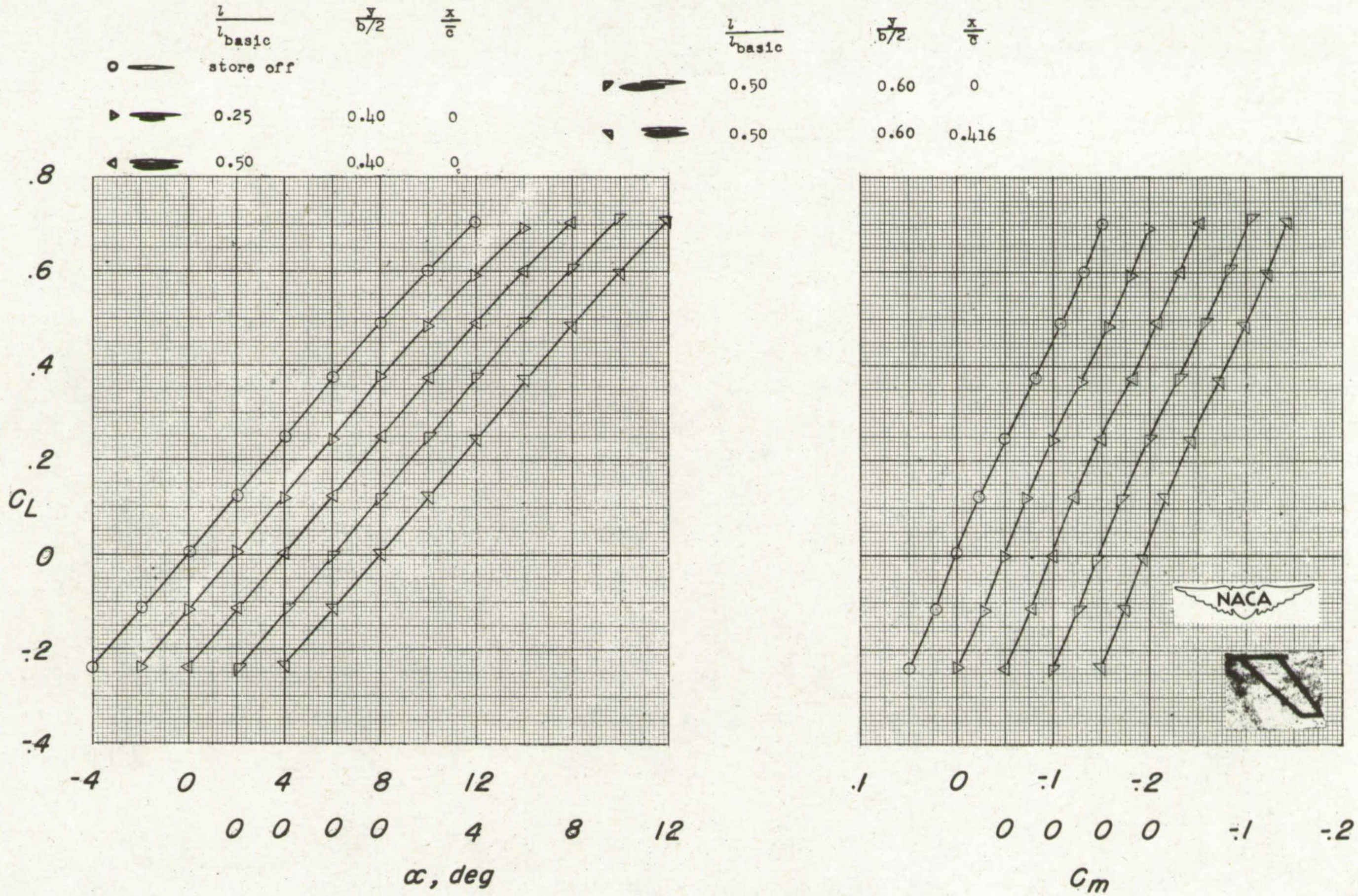
(a) C_L against α and C_m.

Figure 16.- Aerodynamic characteristics of the 45° sweptback wing with DAC stores of various size at one spanwise and two chordwise locations. $M = 1.41$; $R \approx 1.5 \times 10^6$; $\frac{y}{b/2} = 0.80$.



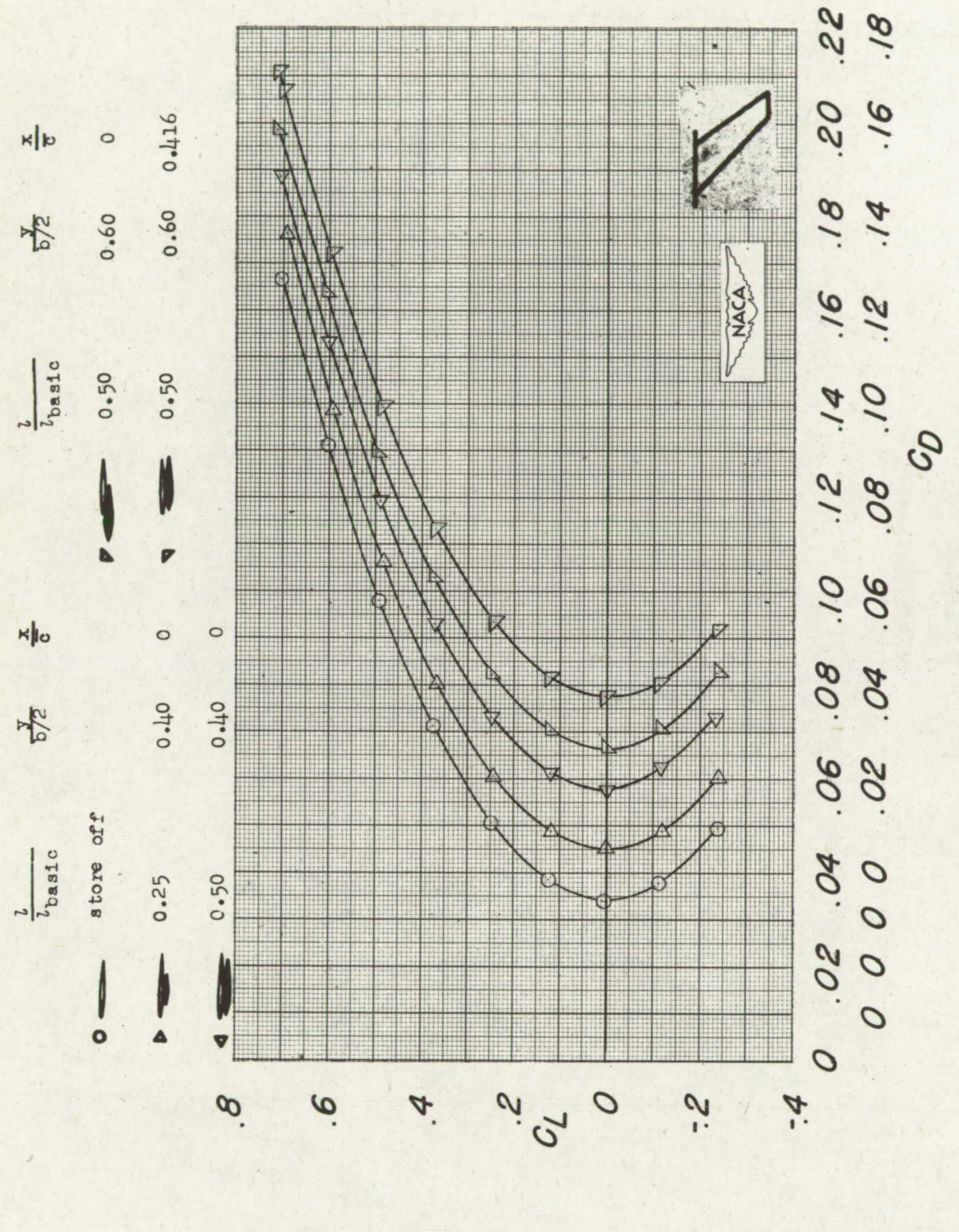
(b) C_L against C_D.

Figure 16.- Concluded.



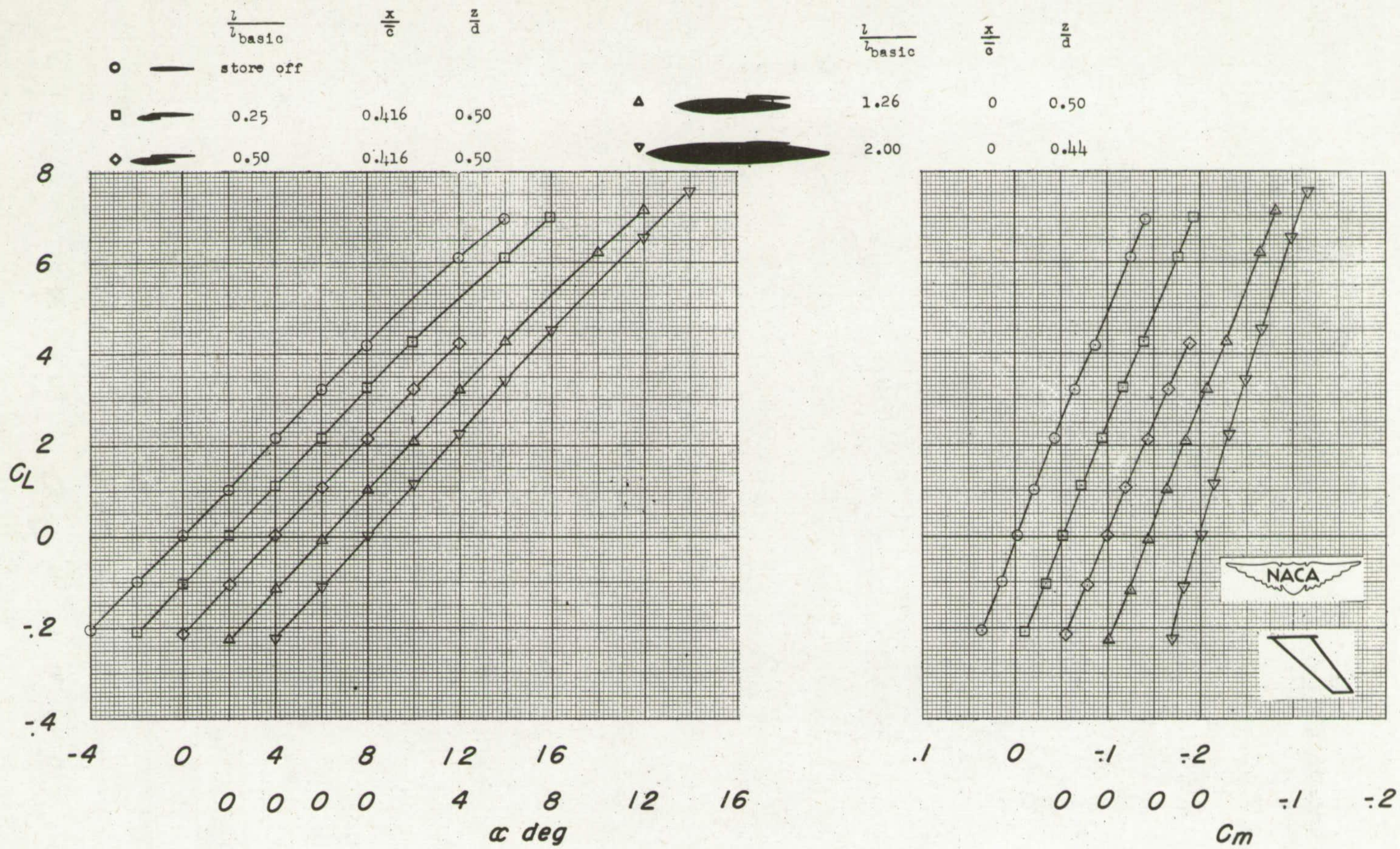
(a) C_L against α and C_m.

Figure 17.- Aerodynamic characteristics of the 45° sweptback wing with DAC stores of various size at several spanwise and chordwise locations. $M = 1.41$; $R \approx 1.5 \times 10^6$; $\frac{z}{d} = 0.50$.



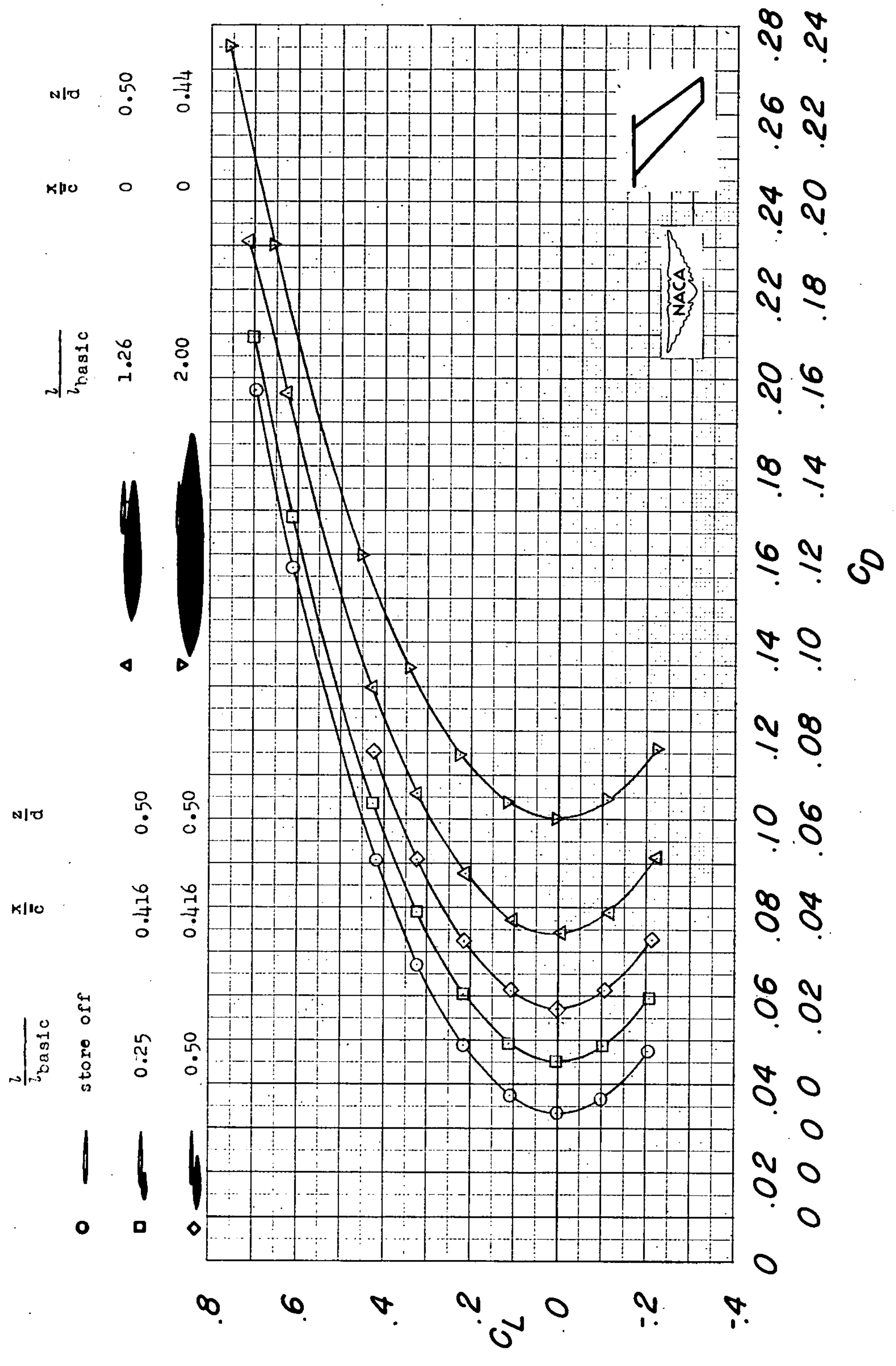
(b) C_L against C_D.

Figure 17.- Concluded.



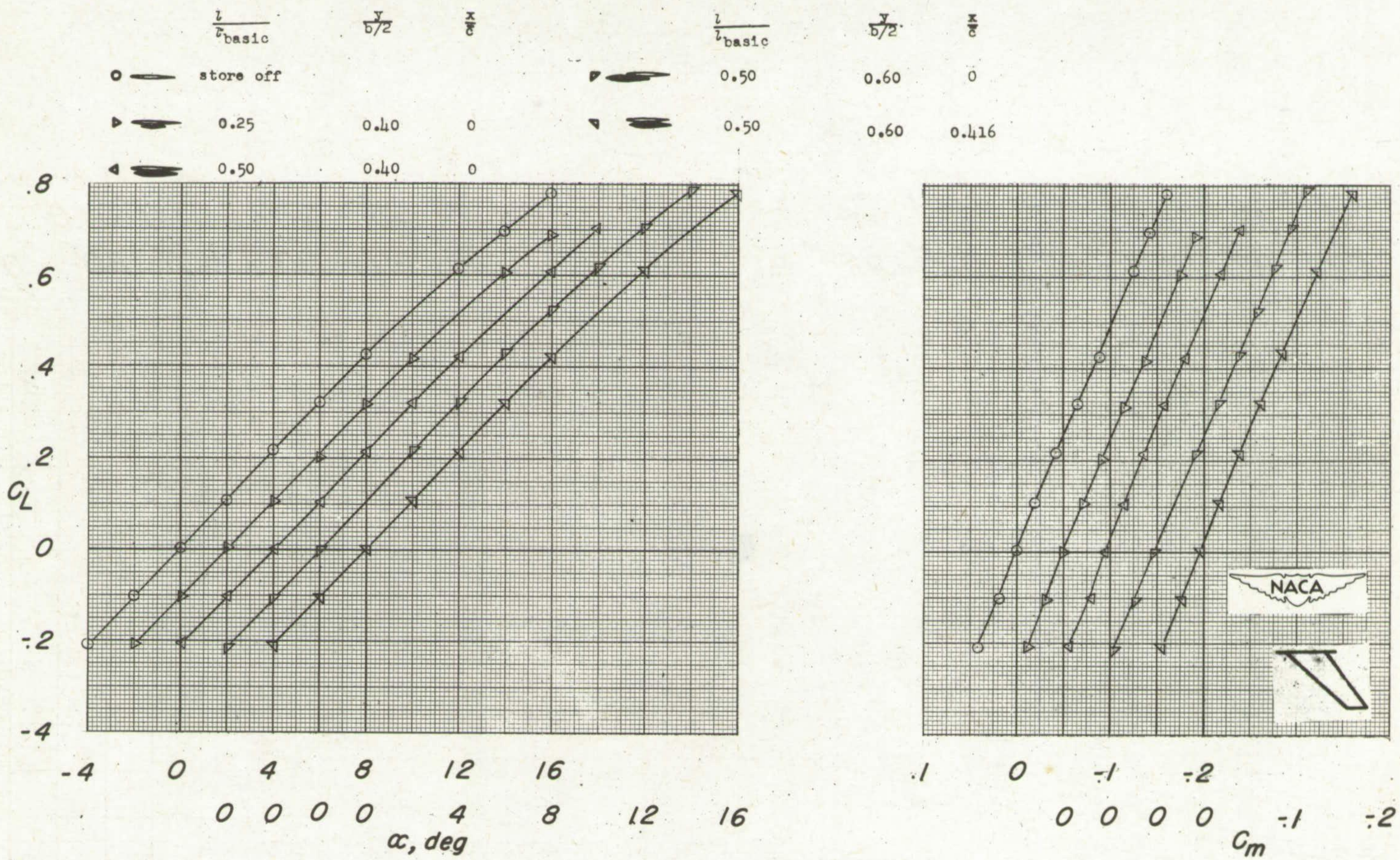
(a) C_L against α and C_m.

Figure 18.- Aerodynamic characteristics of the 45° sweptback wing with DAC stores of various size at one spanwise and two chordwise locations. $M = 1.62$; $R \approx 1.4 \times 10^6$; $\frac{y}{b/2} = 0.80$.



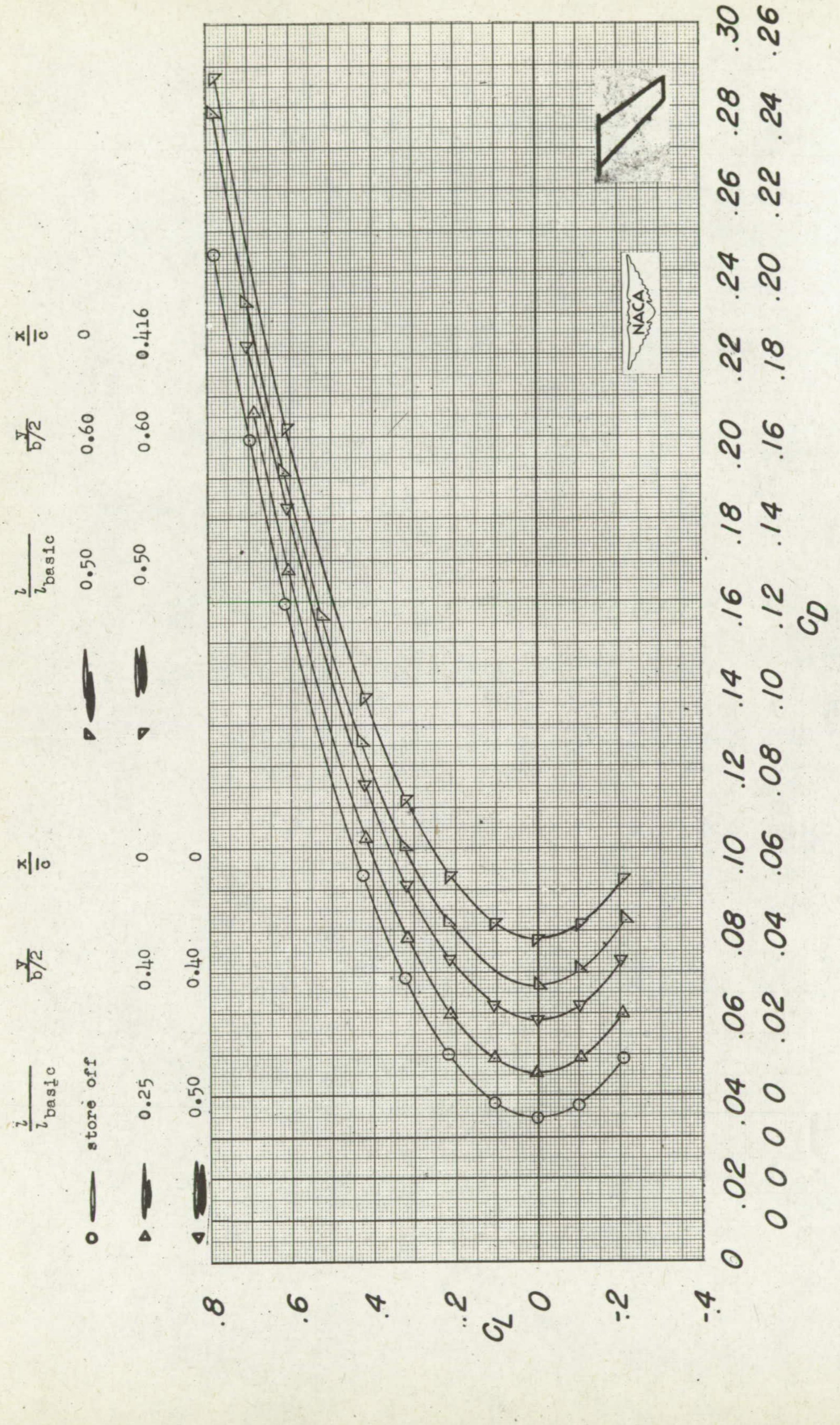
(b) C_L against C_D.

Figure 18.- Concluded.



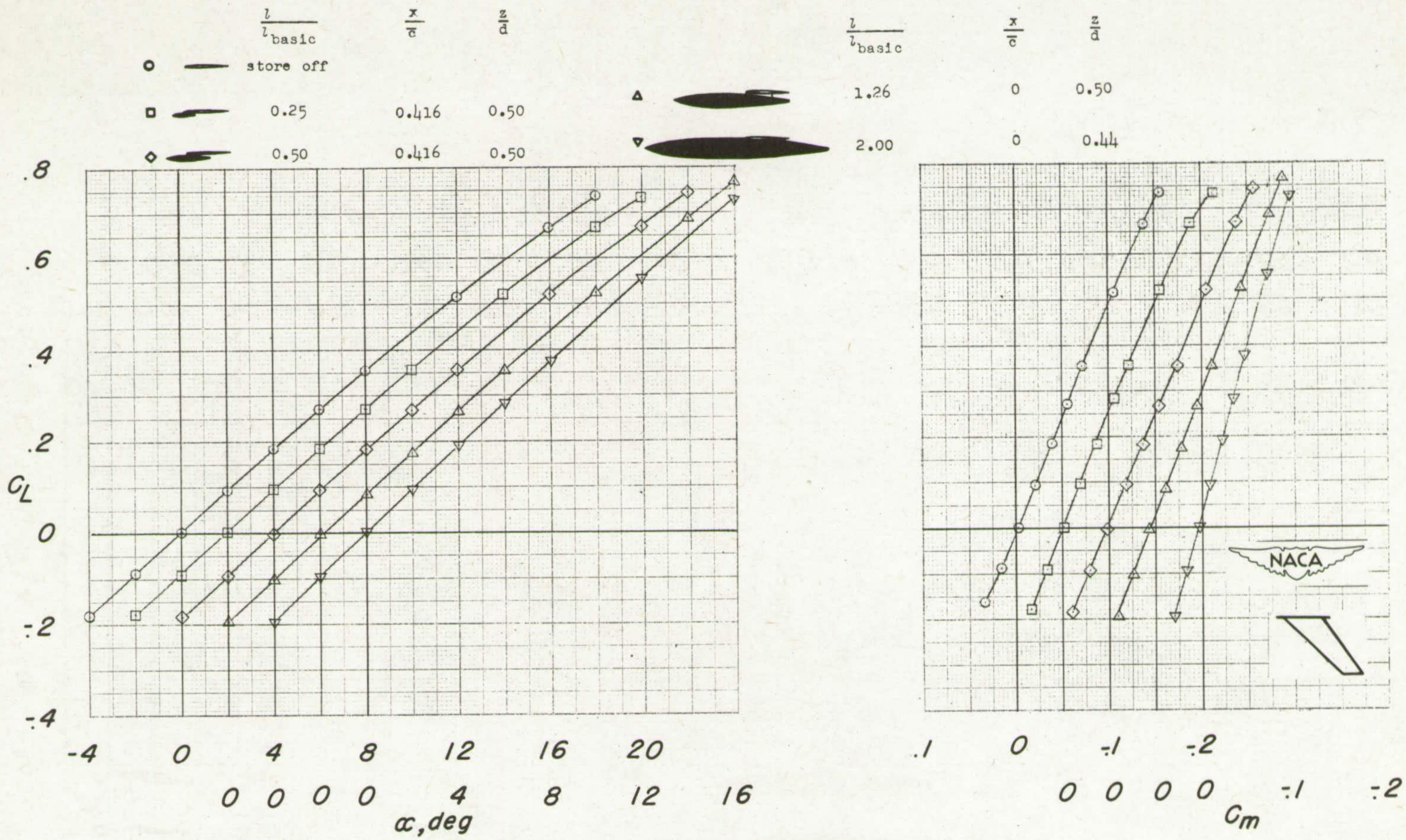
(a) C_L against α and C_m.

Figure 19.- Aerodynamic characteristics of the 45° sweptback wing with DAC stores of various size at several spanwise and chordwise locations. $M = 1.62$; $R \approx 1.4 \times 10^6$; $\frac{z}{d} = 0.50$.



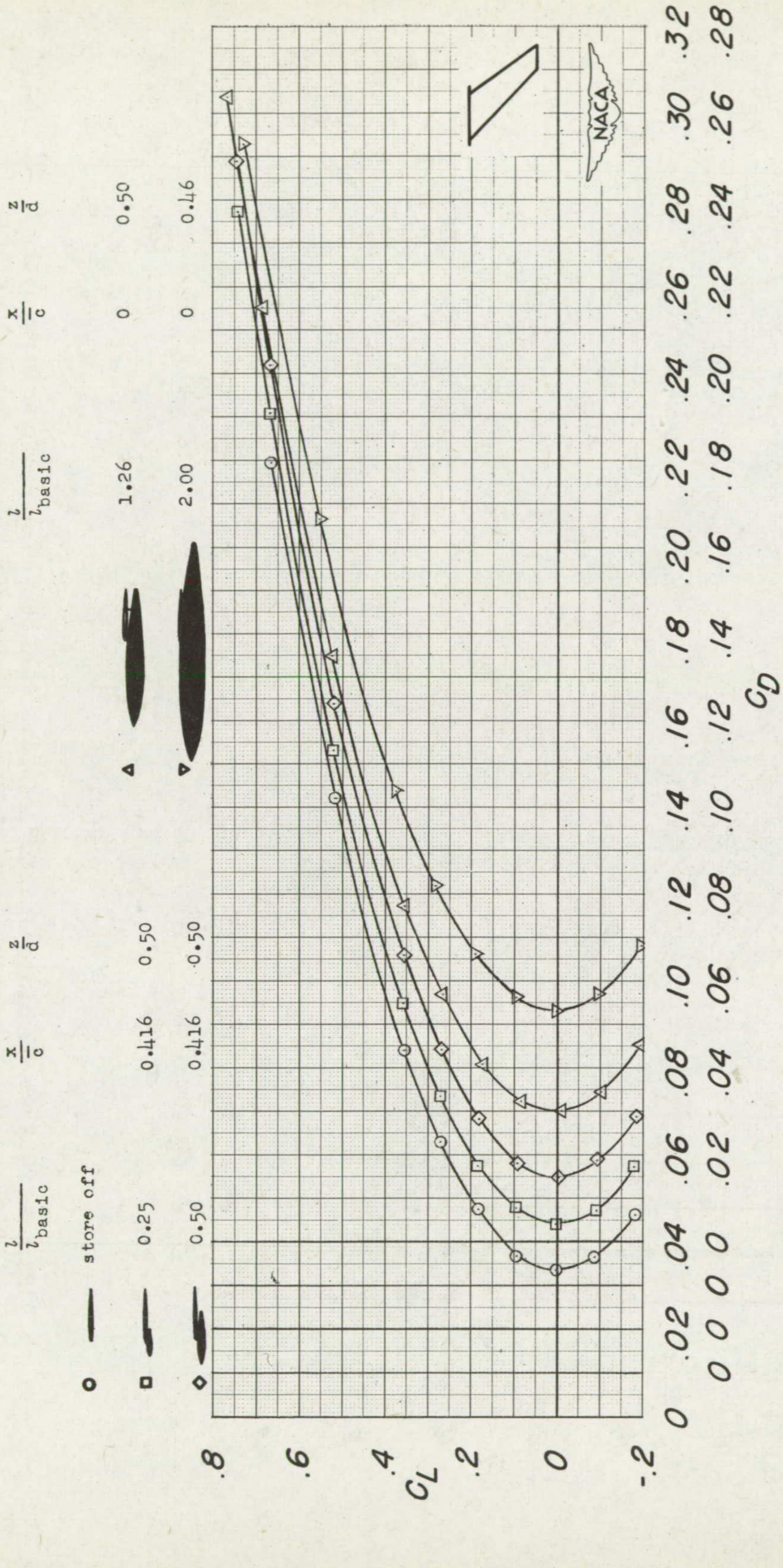
(b) C_L against C_D.

Figure 19.- Concluded.



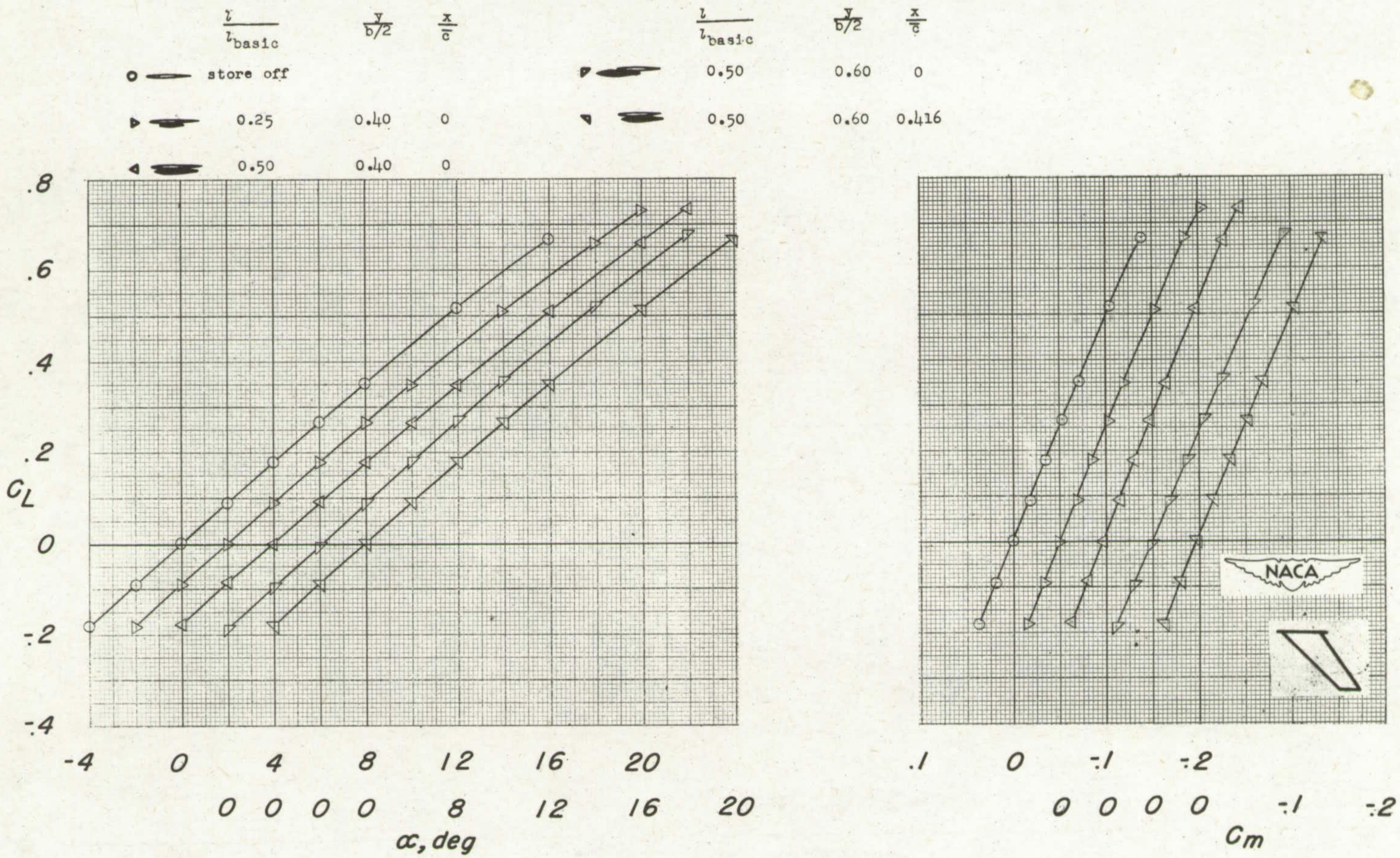
(a) C_L against α and C_m.

Figure 20.- Aerodynamic characteristics of the 45° sweptback wing with DAC stores of various size at one spanwise and two chordwise locations. $M = 1.96$; $R \approx 1.3 \times 10^6$; $\frac{y}{b/2} = 0.80$.



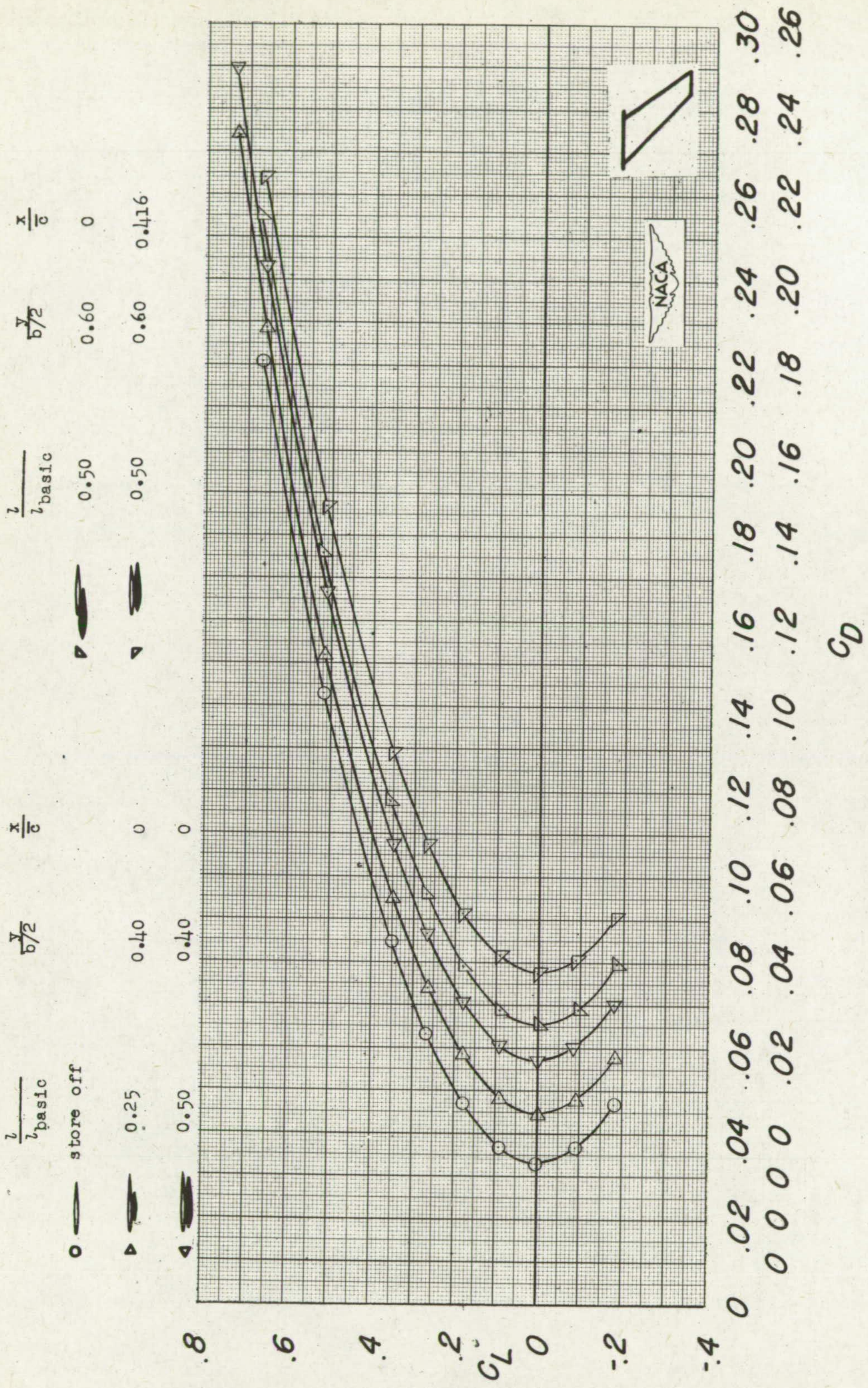
(b) C_L against C_D.

Figure 20.- Concluded.



(a) C_L against α and C_m.

Figure 21.- Aerodynamic characteristics of the 45° sweptback wing with DAC stores of various size at several spanwise and chordwise locations. $M = 1.96$; $R \approx 1.3 \times 10^6$; $\frac{z}{d} = 0.50$.



(b) C_L against C_D.

Figure 21.- Concluded.

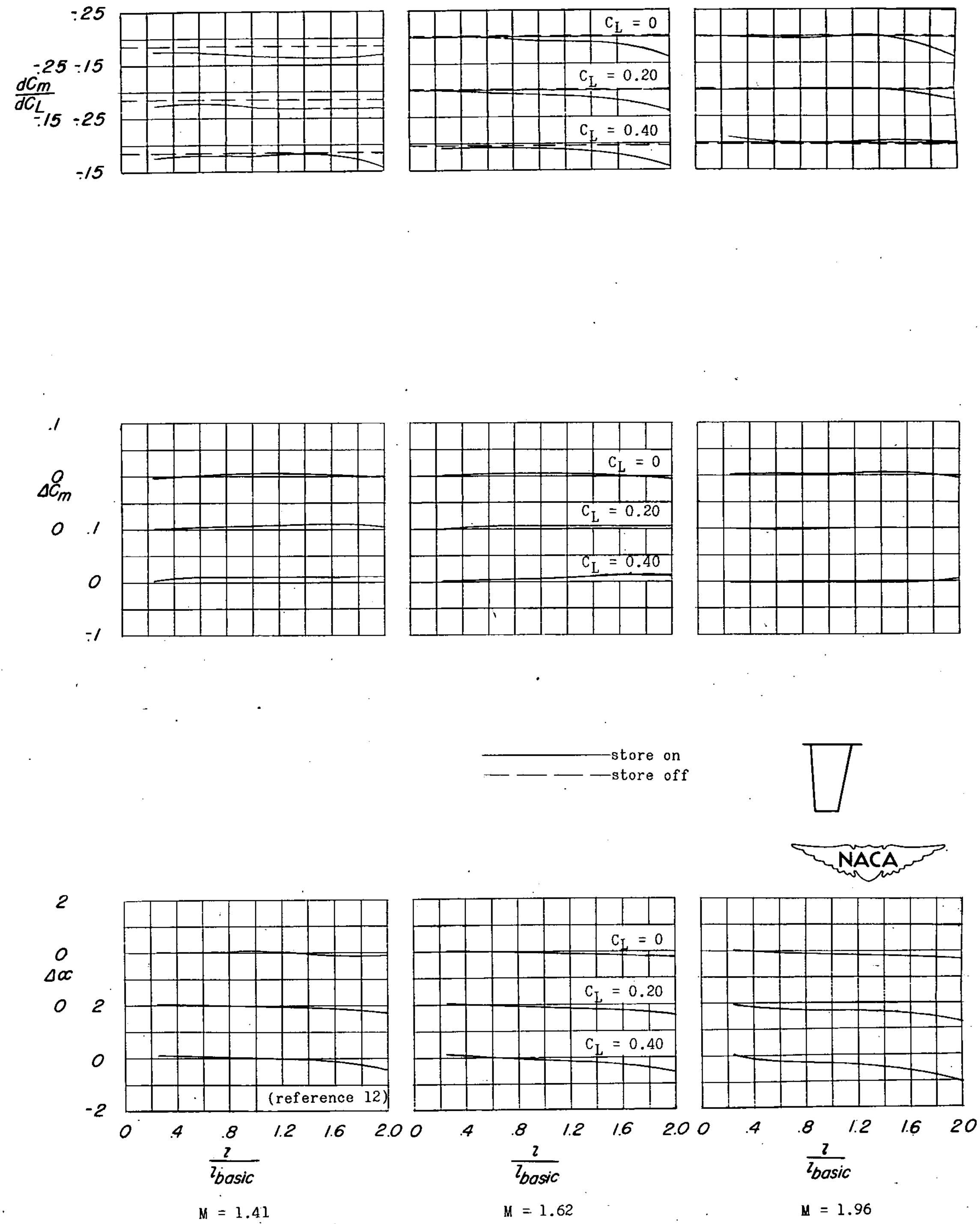


Figure 22.- Effects of store size on $\frac{dC_m}{dC_L}$, ΔC_m, and $\Delta\alpha$ for unswept wing. Stores located at $\frac{y}{b/2} = 0.80$; $\frac{x}{c} = 0$; $\frac{z}{d} = 0.50$ and 0.46.

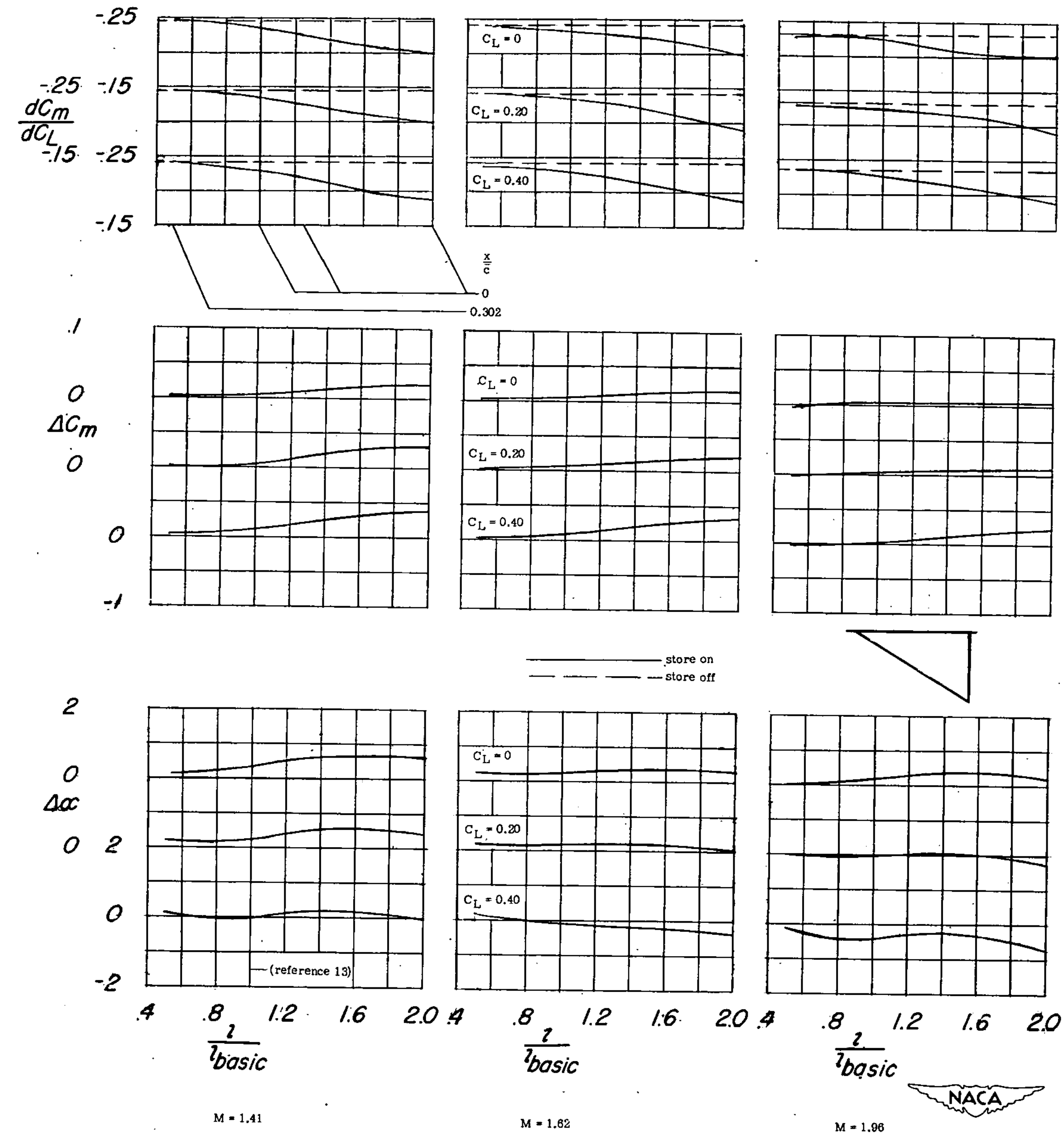


Figure 23.- Effects of store size on $\frac{dC_m}{dC_L}$, ΔC_m, and $\Delta\alpha$ for 60° delta wing. Stores located at $\frac{y}{b/2} = 0.60$; $\frac{x}{\bar{c}} = 0$ and 0.302; $\frac{z}{d} = 0.50$ and 0.46.

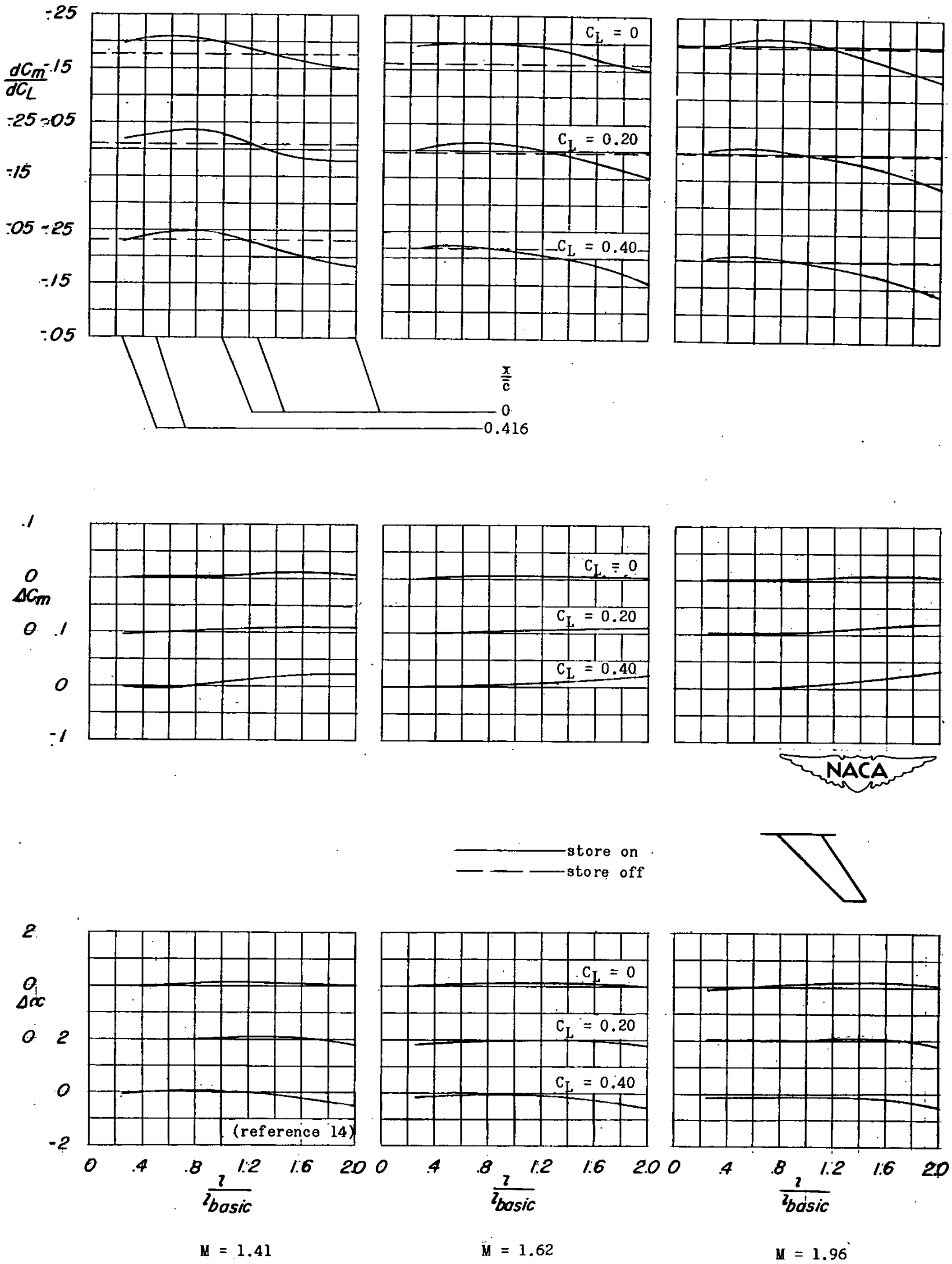
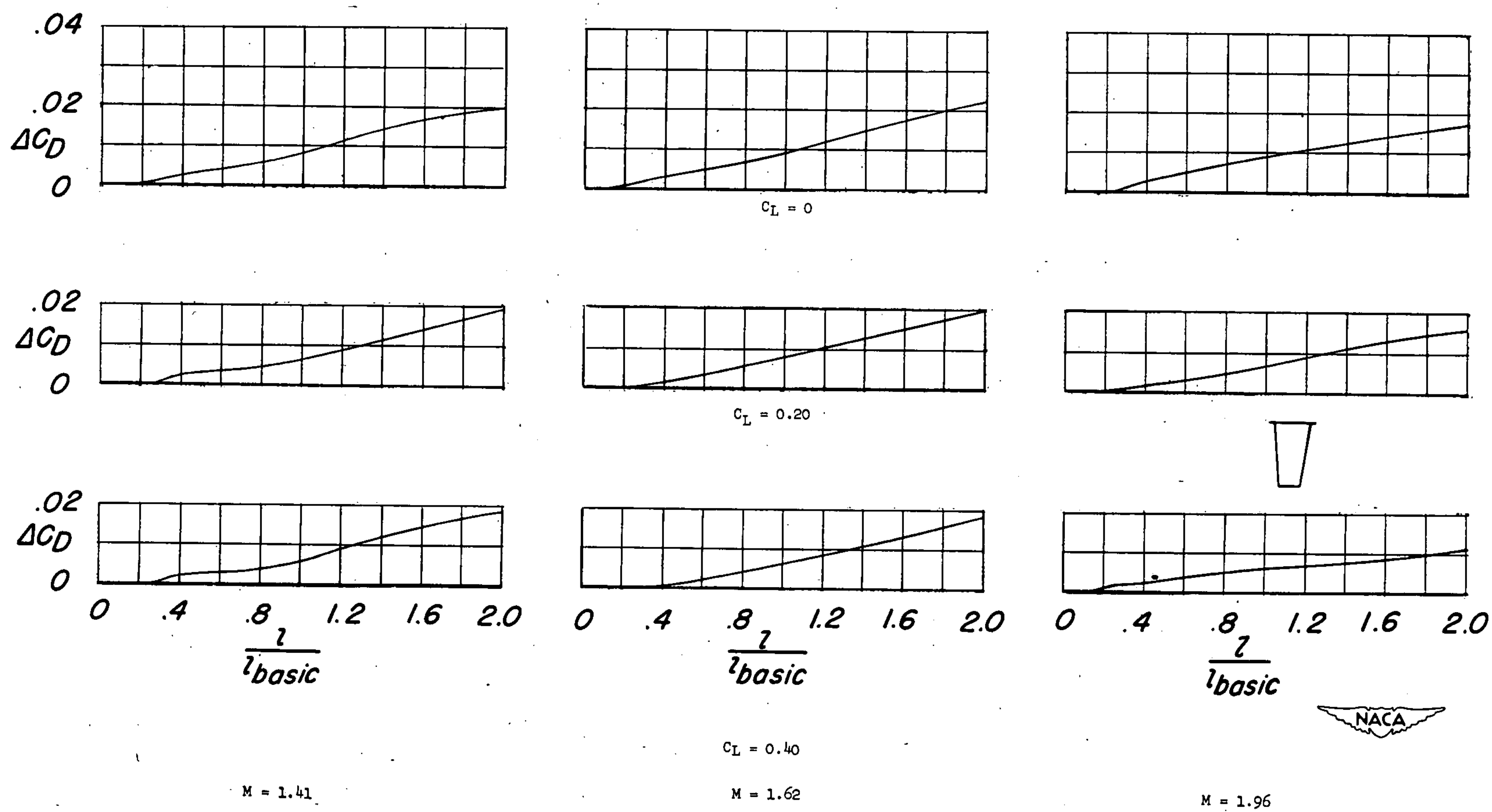
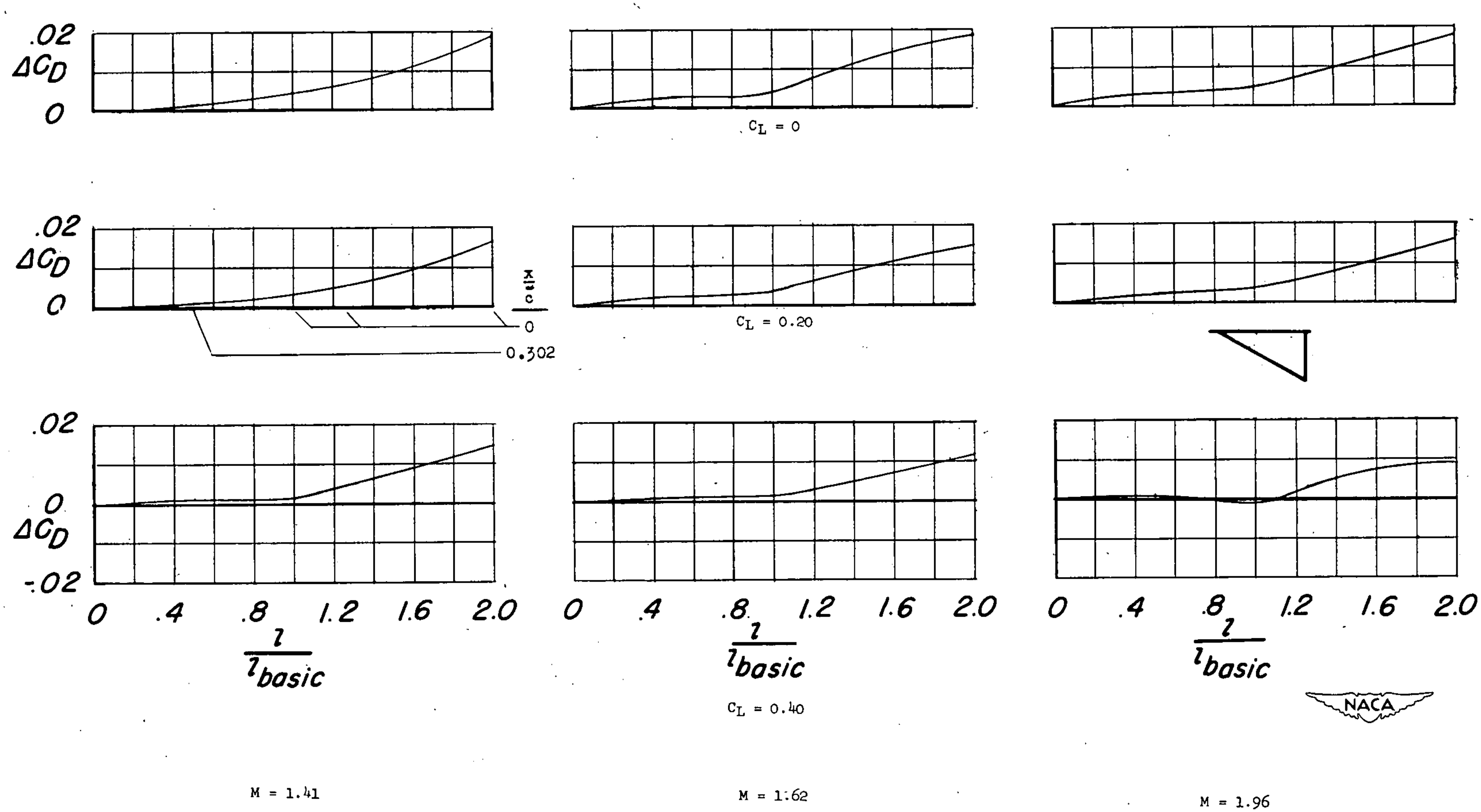


Figure 24.- Effects of store size on $\frac{dC_m}{dC_L}$, ΔC_m, and $\Delta\alpha$ for 45° sweptback wing. Stores located at $\frac{y}{b/2} = 0.80$; $\frac{x}{c} = 0$ and 0.416; $\frac{z}{d} = 0.50$ and 0.44.



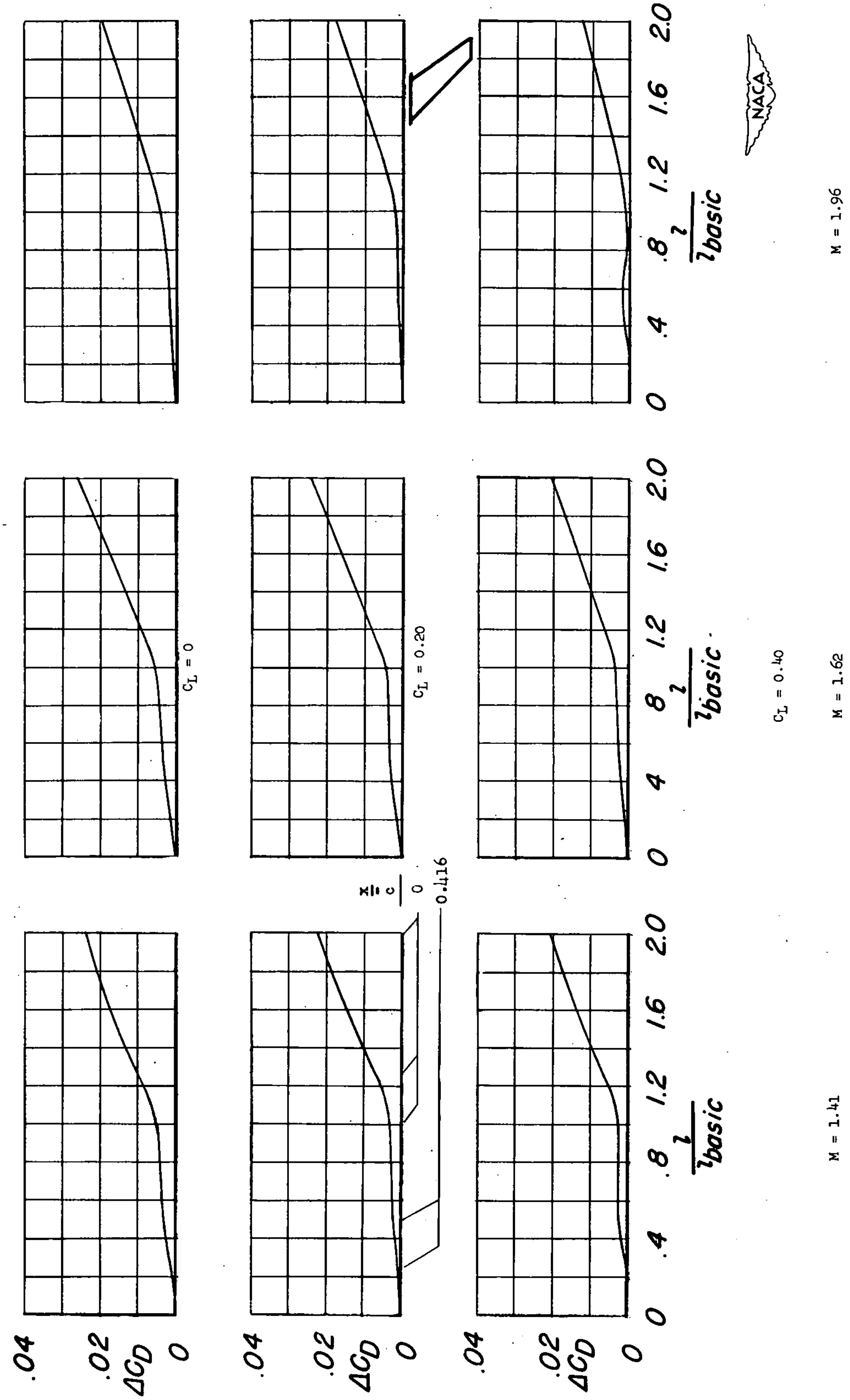
(a) Unswept wing; $\frac{y}{b/2} = 0.80$; $\frac{x}{\bar{c}} = 0$; $\frac{z}{d} = 0.50$ and 0.46.

Figure 25.- Effects of DAC stores of various size on ΔC_D.



(b) 60° delta wing; $\frac{y}{b/2} = 0.60$; $\frac{x}{c} = 0$ and 0.302; $\frac{z}{d} = 0.50$ and 0.46.

Figure 25.- Continued.



(c) 45° sweptback wing; $\frac{y}{b/2} = 0.80$; $\frac{x}{c} = 0$ and 0.416; $\frac{z}{d} = 0.50$ and 0.44.

Figure 25.- Concluded.